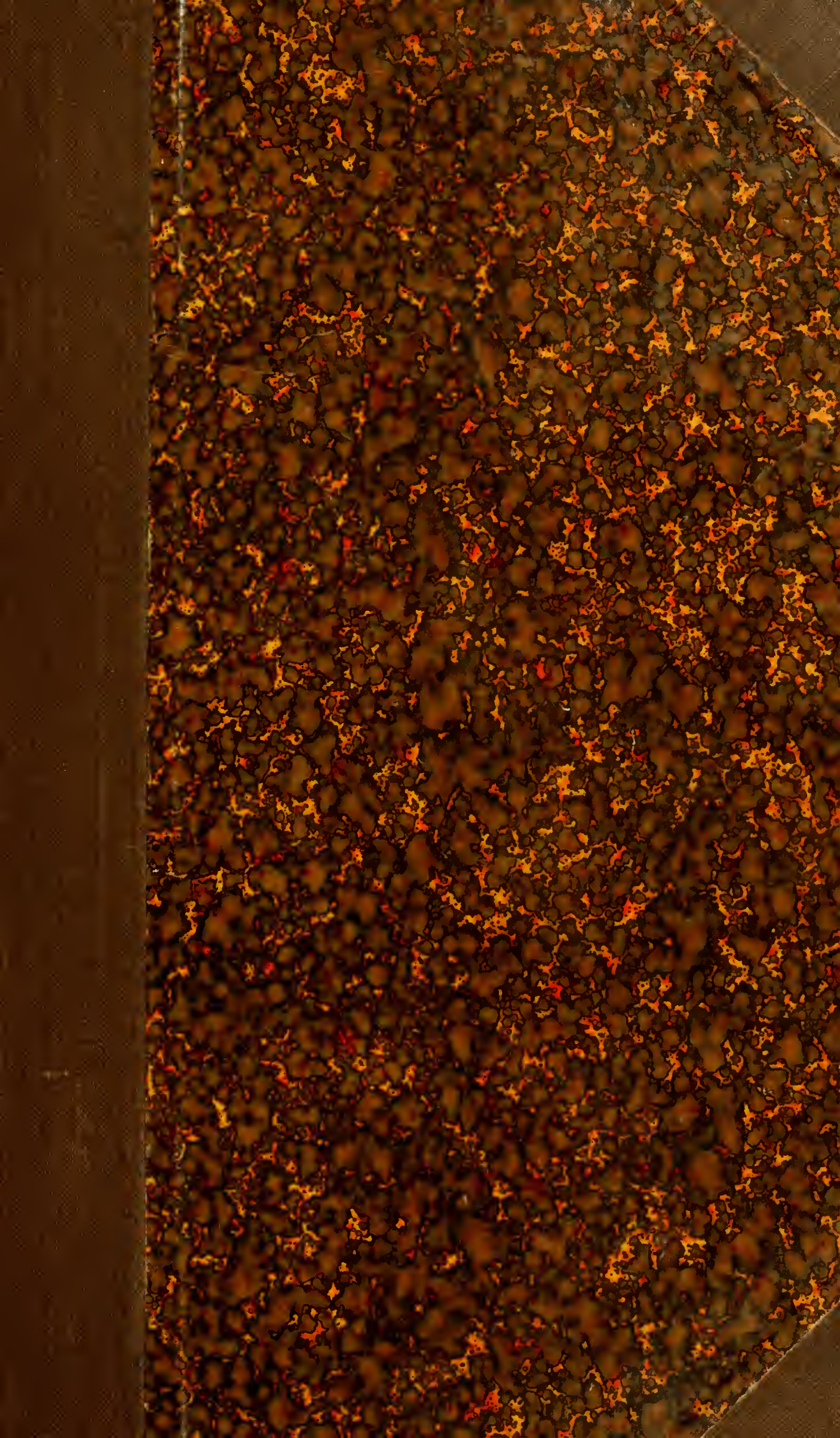

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May 30, 1904 – March 6, 1905

# TRANSACTIONS

OF

# THE ACADEMY OF SCIENCE OF ST. LOUIS.

VOL. XIV.

JANUARY 1904 TO DECEMBER 1904.

PUBLISHED UNDER DIRECTION OF THE COUNCIL.

ST. LOUIS:
NIXON-JONES PRINTING CO.

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## CORRECTIONS.

P. 7, line 35. — For fiind, read find.

P. 115, line 11 from bottom. — For (56) read (55).

P. 120, line 4 from bottom. —For $1.502 \times 10^{10}$ read $1.502 \times 10^{7}$.

P. 125, line 23. — For by, read be.

P. 160. Equation (41) and preceding equation for $Cp$ read $C_p$. (See Vol. XIII.)

P. 165, line 29. — For a, read or.

## MEMBERS.

### 1. PATRONS.

Eliot, Henry W.....1212 Mo. Trust bldg.
Harrison, Edwin.....509 Security bldg.
McMillan, Mrs. Eliza.....25 Portland pl.
McMillan, William Northrop.....507 Lincoln Trust bldg.

### 2. HONORARY MEMBERS.

Arrhenius, Prof. Svante.....University of Stockholm, Sweden.
Bahlsen, Prof. Dr. Leopold.....Berlin, Germany.
Boltzmann, Prof. Ludwig.....University of Vienna, Austria.
Chavero, Señor Alfredo.....National Museum, Mexico.
Escherich, Prof. Theodore. .....University of Vienna, Austria.
Kitasato, Prof. Shibasaburo.....University of Tokio, Japan.
Lewald, Geh. Oberreg. Rath Theodor.....Berlin, Germany.
Limburg, Stirum, Graf.....Berlin, Germany.
Moissan, Prof. Henri.....Sorbonne, Paris, France.
Orth, Geh. Rath Dr. Johann.....University of Berlin, Germany.
Oswald, Prof. Wilhelm.....University of Leipzig, Germany.
Ramsay, Sir William.....Royal Institute, London, England.
Rutherford, Prof. Ernest.....McGill University, Montreal, Canada.
Van 't Hoff, Prof. J. W.....University of Berlin, Germany.
Waldeyer, Geh. Rath Prof. Dr. Wilhelm.....University of Berlin, Germany.
Wassermann, Prof. Dr. A.....University of Berlin, Germany.
Wittmack, Geh. Reg. Rath Prof. Dr. L.....University of Berlin, Germany.

### 3. ACTIVE MEMBERS.

Adkins, James.....Park and Vandeventer avs.
Alleman, Gellert*.....Swarthmore College, Swarthmore, Pa.

* Non-resident.

Allen, Terry W.....5061 Lindell av.
Alt, Adolf.....3036 Locust st.
Altheimer, Benjamin.....4349 Westminster pl.
Andrews, William Edward*.....Taylorville, Ill.

Bain, Robert Edward Mather.....900 Locust st.
Bailey, Liberty Hyde*.....Ithaca, N. Y.
Baker, Carl Fuller*.....Etacion Central Agronomica, Santiago de las Vegas, Cuba.
Barck, Carl.....2715 Locust st.
Bartlett, George M.....215 Pine st.
Baumgarten, Gustav.....4900 Berlin av.
Becktold, William B.....212 Pine st.
Bernays, A. C.....3623 Laclede av.
Bernays, Walter.....Office of City Chemist.
Bixby, William Keeney.....13 Portland pl.
Boeckeler, William L.....4441 Laclede av.
Bolton, Benjamin Meade.....4201 Maryland av.
Boyle, Wilbur F.....Laclede bldg.
Brannon, Melvin A.*.....University, N. Dak.
Brennan, Martin S.....1414 O'Fallon st.
Brimmer, George G.....6900 Michigan av.
Brookings, Robert S.....5125 Lindell av.
Brown, Daniel S.....2212 DeKalb st.
Brown, Willi.....3526 Pine st.
Budgett, Sidney Payne.....1806 Locust st.
Burg, William.....1756 Missouri av.
Burnett, E. C.....University Club.
Busch, Adolphus.....1 Busch pl.
Busch, Aug. A.....Busch pl.
Bush, Benjamin Franklin*.....Courtney, Mo.

Calvert, Sidney*.....State University, Columbia, Mo.
Carpenter, George O.....Russell and Compton avs.
Carter, Howard*.....Webster Groves, Mo.
Carver, George Washington*.....Tuskegee, Ala.
Chaplin, Winfield S.....3636 West Pine boul.
Chappell, W. G.....3810 Westminster pl.
Chase, E. C.....Oriel bldg.
Chouteau, Pierre.....912 Security bldg.
Comstock, T. Griswold.....3401 Washington av.
Conklin, Harry R.*.....Joplin, Mo.

Cramer, Gustav.....c/o G. Cramer Dry Plate Co.
Crandall, George C.....4287 Olive st.
Crunden, Frederick Morgan.....Public Library.
Curtis, William S.....St. Louis Law School.
Cushman, Allerton S.*.....Bryn Mawr, Pa.

Dame, James E.....2353 Albion pl.
Dameron, Edward Caswell*.....Clarksville, Mo.
Davis, N. H..... 56 Vandeventer pl.
Davis, John D.....421 Olive st.
De Menil, Alexander N.....De Menil bldg., 7th and Pine sts.
Diehm, Ferdinand.....1834 Kennett pl.
Dodd, Samuel M..... 415 Locust st.
Douglas, Archer W.....c/o Simmons Hardware Co.
Drake, George S.....64 Vandeventer pl.
Drosten, F. W.....2011 Park av.
Duggar, B. M.*.....809 Virginia av., Columbia, Mo.

Eimbeck, August F.*.....New Haven, Mo.
Eliot, Edward C.....5468 Maple av.
Engler, Edmund Arthur*.....11 Boynton st., Worcester, Mass.
Erker, Adolph P.....608 Olive st.
Espenschied, Charles.....3500 Washington av.
Euston, Alexander .....3730 Lindell boul.
Evers, Edward.....1861 N. Market st.
Ewing, Arthur E.....5944 West Cabanne pl.
Eycleshymer, A. E.....3850 Washington av.

Favor, Ernest Howard*..... .....Box 842, Columbia, Mo.
Fernald, Robert Heywood.....Washington University.
Fischel, Washington E.....3841 Washington av.
Forbes, Stephen A.*.....Urbana, Ill.
Fordyce, John R.*.....2223 Louisiana st.,
Little Rock, Ark.
Francis, David R.....4421 Maryland av.
French, George Hazen*.....Carbondale, Ill.
Frerichs, Frederick W.....4608 S. Broadway.
Frick, John Henry*.....Warrenton, Mo.
Fruth, Otto J.....3066 Hawthorne boul.
Fry, Frank R..... . ... 3133 Pine st.
Funkhouser, Robert Monroe.....4334 Olive st.

Gazzam, James Breading.....514 Security bldg.
Gecks, Frank.....3453 Magnolia av.
Gerling, H. J.....4320 Cook av.
Glasgow, Frank A.....3894 Washington boul.
Glasgow, William C.....2847 Washington av.
Goldstein, Max A.....3858 Westminster pl.
Goodman, Charles H.....3329 Washington av.
Graf, A. V.....1325 S. 7th st.
Graves, William W.....3900 Olive st.
Graves, Willis Nelson.....2813 Lafayette av.
Green, John.....2670 Washington av.
Gregory, Elisha Hall.....3525 Lucas av.
Gregory, Elisha H., Jr.*.....Medical Dept., Univ. of Pa., Philadelphia.
Grindon, Joseph.....3894 Washington av.
Gundelach, Chas. H.....3900 Westminster pl.
Gundelach, W. J.....3703 Finney av.
Gurney, James.....Tower Grove and Magnolia avs.
Guy, William Evans.....26 Laclede bldg.

Haarstick, Henry C.....103 Chamber of Commerce.
Hambach, Gustav†.....1319 Lami st.
Hardaway, W. A.....2920 Locust st.
Harris, James Arthur.....Mo. Botanical Garden.
Hartmann, Rudolph.....2020 Victor st.
Held, George A.....International Bank.
Herzog, William.....3644 Botanical av.
Hirschberg, Francis D.....3818 Lindell boul.
Hitchcock, Albert Spear*.....U. S. Dept. Agriculture, Washington, D. C.
Hitchcock, George C.....709 Wainwright bldg.
Homan, George.....323 Odd Fellows' bldg.
Hough, Warwick.....Circuit Court, Room 1.
Hughes, Charles Hamilton.....3860 West Pine boul.
Hume, H. Harold*.....Dept. of Agriculture, Raleigh, N. C.
Hunicke, Henry August.....3532 Victor st.
Hurter, Julius.....2346 S. 10th st.
Huston, Hy. A.....134 Laclede bldg.

† Elected a life-member January 3, 1882.

Irish, Henry C.....Mo. Botanical Garden.
Ives, Halsey Cooley .....Museum of Fine Arts.

Jones, Breckinridge.....4010 Lindell boul.

Kall, Richard..... .....1370 Goodfellow av.
Keiser, Edward H..... .....Washington University.
Kinealy, John H.....619 Granite bldg.
King, Goodman..... .....78 Vandeventer pl.
Kirchner, Walter C. G. .... .....1211 N. Grand av.
Klem, Mary J .....1808½ Lafayette av.
Koch, Waldemar H. A.* .....State University, Columbia, Mo.

Lackland, Rufus J .....1623 Locust st.
Langsdorf, Alexander S .....Washington University.
Lange, Th .....2709 Gamble st.
Leavitt, Sherman.....Washington University.
Lefevre, George* .....State University, Columbia, Mo.
Leighton, George Bridge.....803 Garrison av.
Letterman, George W.*.....Allenton, Mo.
Lichter, John J.....1740 Simpson av.
Lloyd, Hiram.....Odd Fellows' bldg.
Loeb, Hanau Wolf.....3559 Olive st.
Ludwig, Charles V. F.....1509 Chouteau av.
Luedeking, Robert.....1837 Lafayette av.
Lumelius, J. George.....1225 St. Ange av.
Lyon, Hartwell Nelles .....3918 Russell av.

Mack, Charles Jacob .....113 N. Broadway.
Mallinckrodt, Edward..... . .....26 Vandeventer pl.
Mallinckrodt, Edward, Jr.....26 Vandeventer pl.
Markham, George Dickson.....4961 Berlin av.
Marx, Christian William* .....University of Cincinnati,
Cincinnati, O.
Mason, Silas C.*.....Berea, Ky.
Matthews, Leonard..... .....300 N. 4th st.
McBride, W. J..... .....5093 Washington av.
McGee, W J.....World's Fair.
Meier, Theodore G.....5220 Washington boul.
Merrell, Albert .....3814 Washington boul.
Michel, Eugene H.....2721 S. King's Highway.
Miller, Charles F.....1751 Missouri av.

Monell, Joseph T.*.....Flat River, Mo.
Monroe, Lee Ernest*.....Eureka, Mo.
Moore, Robert.....61 Vandeventer pl.
Mudd, Harvey G.....2604 Locust st.
Mueller, Ambrose*.....Webster Groves, Mo.

Nagel, Charles.....3969 Washington boul.
Nasse, Aug.....209 N. 2d st.
Nautze, Gustav.....2868 S. 18th st.
Nelson, Aven*.....Laramie, Wyom.
Niedringhaus, George W.....3745 Lindell boul.
Nipher, Francis E.....Washington University.
Norton, J. B. S.*.....College Park, Md.

Oglevee, Christopher Stoner*.....Lincoln, Ill.
Olshausen, Ernest P.....1115 Rutger st.
Olshausen, George R.*.....Cornell University, Ithaca, N. Y.
O'Reilly, Andrew J.....1507 Papin st.
O'Reilly, Robert J.....3411 Pine st.
Outten, W. B.....Missouri Pacific Hospital.
Overstolz, Herman.....106 N. Broadway.

Palmer, Ernest Jesse*.....321 S. Allen st., Webb City, Mo.
Pammel, Louis Hermann*.....Ames, Ia.
Pantaleoni, Guido.....415 Locust st.
Parker, George Ward*.....45 Broadway, New York City.
Parsons, Charles.....2804 Pine st.
Pauls, Gustavus.....St. Louis Altenheim.
Pettus, W. H. H.....4373 Westminster pl.
Pfeiffer, Egmont.....2007½ Penn st.
Pike, Sherman B.....415 Locust st.
Pitzman, Julius.....1900 S. Compton av.
Poats, Thomas Grayson*.....Clemson College, S. C.
Post, Martin Hayward.....5371 Waterman av.
Preetorius, Emil.....c/o Westliche Post.
Prynne, Charles Martyn.....Lincoln Trust bldg.
Pulsifer, William H.*.....The Highlands, Washington, D. C.

Quaintance, A. L.*.....U. S. Department of Agriculture, Washington, D. C.

Randall, John E.*..... Cleveland Lamp Factory, Cleveland, O.
Raphael, Abraham.....5164 Raymond av.
Ravold, Amand.....2806 Morgan st.
Reed, Howard S.*.....1002 Lowery st., Columbia, Mo.
Reverchon, Julien*.....R. F. D. 8, Dallas, Texas.
Rice, Chas. M.....3733 Pine st.
Richter, Phil. George.....2424 S. 18th st.
Rieloff, F. C.....3837 W. Pine boul.
Rilliet, Chas. E.....3018 N. Newstead av.
Robert, Edward Scott.....1105 Missouri Trust bldg.
Robertson, Charles*.....Carlinville, Ill.
Roever, William Henry*.....Cambridge, Mass.
Rolfs, Peter H.*.....Tropical Laboratory, Miami, Fla.
Rosenwald, Lucian*.....412 Delaware st., Kansas City, Mo.
Ruf, Frank A.....5863 Cabanne av.
Ryan, Frank K.....2725 Lawton av.

Sander, Enno.....2807 Lawton av.
Sargent, Charles Sprague*.....Jamaica Plain, Mass.
Schmitz, R.....6th and St. Charles sts.
Schneck, Jacob*.....Mt. Carmel, Ill.
Von Schrenk, Hermann.....Mo. Botanical Garden.
Schroers, John.....1730 Missouri av.
Schrowang, Otto.....Gay bldg.
Schwab, Sidney I.....2602 Locust st.
Schwarz, Frank.....1520 Lafayette av.
Schwarz, Henry.....440 N. Newstead av.
Schweitzer, Paul*.....Columbia, Mo.
Scott, Henry C.....64 Vandeventer pl.
See, Thomas Jefferson Jackson*..Naval Observatory, Mare Island, Cal.
Selby, Augustine Dawson*.....Wooster, O.
Senseney, E. M.....2829 Washington av.
Sheldon, Walter L.....4065 Delmar av.
Shepley, John F.....60 Vandeventer pl.
Shoemaker, William Alfred.....4386 Westminster pl.
Siebert, A.....1647 S. Jefferson av.
Simmons, E. C.....9th and Spruce sts.
Simmons, Wallace D.....9th and Spruce sts.
Sluder, Greenfield.....2647 Washington av.
Smith, Arthur George*.....422 N. Dubuque st., Iowa City, Ia.

Smith, D. S. H.....3646 Washington boul.
Smith, Irwin Z.....87 Vandeventer pl.
Smith, Jared G.*.....Honolulu, Hawaiian Islands.
Soldan, F. Louis.....3634 Flad av.
Spiegelhalter, Joseph.....2166 Lafayette av.
Starkloff, H. M.....3623 Cleveland av.
Starr, John E.*.....258 Broadway, New York City.
Staudinger, B.....3556 Lindell boul.
Stedman, John Moore*.....State University, Columbia, Mo.
Stevens, Charles D.....1749 S. Grand av.
Stevens, Wyandotte James.....4043 Juniata st.
Stocker, George J.....2833 S. King's Highway.
Summa, Hugo.....2249 St. Louis av.

Taussig, Albert E.....2647 Washington av.
Taussig, William.....3447 Lafayette av.
Teichmann, William C.....Mallinckrodt Chemical Works.
Terry, Robert James.....1806 Locust st.
Thacher, Arthur.....4304 Washington boul.
Thomas, John R.....4128 Washington av.
Thurman, John S.....3933 Olive st.
Timmerman, Arthur H.....2017 Locust st.
Tittmann, Harold H.....28 Westmoreland pl.
Trelease, William.....Mo. Botanical Garden.
Tyler, Elza Edward*.....State University, Columbia, Mo.
Tyrrell, Warren Ayers.....620 Chestnut st.

Updegraff, Milton*.....12 Goldsborough Row,
Annapolis, Md.

Vallé, Jules F.....3303 Washington av.
Van Ornum, John Lane.....Washington University.
Vickroy, Wilhelm Rees.....2901 Rauschenbach av.

Walter, Jacob.....1931 S. Compton av.
Warren, William Homer.....1806 Locust st.
Watts, Millard F.....4362 Morgan st.
Weller, Stuart*.....University of Chicago,
Chicago, Ill.
Westgate, John Minton*.....Dept. of Agriculture,
Washington, D. C.
Wheeler, H. A.....3124 Locust st.

Whelpley, Henry Milton.....2342 Albion pl.
Whitaker, Edwards.....300 N. 4th st.
Whitten, John Charles*.....Columbia, Mo.
Widmann, Otto..... ..... 5105 Morgan st.
Wilson, Edward Allen..... .....3745 W. Pine st.
Winkelmeyer, Christopher.....3540 Lawton av.
Wislizenus, Frederick A.....808 Wainwright bldg.
Witt, Thomas D.....6th and Olive sts.
Wolff, Herbert W.....3514 Shenandoah st.
Woodward, Calvin Milton.....Washington University.
Wright, Geo. M.....4457 Westminster pl.

Zahorsky, John.....1460 S. Grand av.
Zawodny, Joseph*..... .....Schloss Lobes, Mscheno bei Melnik, Bohemia, Austria.
Zollmann, Geo. H.....833 N. 3d st.

# CONSTITUTION.

## ARTICLE I. NAME.

SECTION 1. This Association shall be called "THE ACADEMY OF SCIENCE OF ST. LOUIS."

## ARTICLE II. OBJECT.

SECTION 1. It shall have for its object the promotion of science.

SEC. 2. As means to this end the Academy shall hold meetings for the consideration and discussion of scientific subjects; shall take measures to procure original papers upon such subjects; and shall, as often as may be practicable, publish its transactions. It shall also establish and maintain a cabinet of objects illustrative of the several departments of science, and a library of works relating to the same. It shall also place itself in communication with other scientific institutions.

## ARTICLE III. MEMBERS.

SECTION 1. The Academy shall consist of *Active Members*, *Corresponding Members*, *Honorary Members*, and *Patrons*.

SEC. 2. *Active Members* shall be persons interested in science, and they alone shall conduct the affairs of the Academy.

SEC. 3. Persons not living in the City or County of St. Louis who may be disposed to further the object of the Academy by original researches, contributions of specimens, or otherwise, may be elected *Corresponding Members*.

SEC. 4. Persons not living in the City or County of St. Louis may be elected *Honorary Members* by virtue of their attainments in science.

SEC. 5. Any person conveying to the Academy the sum of one thousand dollars ($1,000), or its equivalent, may be elected a *Patron*.

SEC. 6. Persons may be admitted to any of the preceding classes of membership, or dismissed therefrom, in accordance with the regulations prescribed by the By-Laws.

## ARTICLE IV. OFFICERS.

SECTION 1. The officers of the Academy shall be chosen from the active members, and they shall consist of a

President,
1st Vice-President,
2d Vice-President,
Recording Secretary,
Corresponding Secretary,
Treasurer,
Librarian,
Three Curators,
Two Directors.

Said officers shall be elected at the time and in the manner prescribed by the By-Laws, and shall hold their offices for one year, or until their successors are elected.

SEC. 2. The duties of these officers shall be such as are customary and as prescribed by the By-Laws.

## ARTICLE V. COUNCIL.

SECTION 1. The President, the two Vice-Presidents, the Recording Secretary, the Treasurer, the Librarian, and the two Directors shall constitute the Council of the Academy.

SEC. 2. The duties of the Council shall be to consider all plans conducive to the welfare of the Academy; to audit all bills and order payment of such as they may approve; to consider all applications for membership; and to administer the business of the Academy, subject to the Constitution

and By-Laws and to such instructions as may be given by the Academy.

### ARTICLE VI. MEETINGS.

SECTION 1. The meetings of the Academy shall be held at such times and places as the By-Laws may direct.

### ARTICLE VII. AMENDMENTS.

SECTION 1. Amendments to this Constitution shall be submitted in writing at a regular meeting. They shall be open to discussion until at least the second meeting thereafter. They may then be adopted by a two-thirds vote of a letter-ballot, conducted in the manner prescribed by the Council.

### ARTICLE VIII. SECTIONS.

SECTION 1. To encourage and promote special investigations in any branch of science, members of the Academy may form Sections which shall be constituted as herein provided.

SEC. 2. For the formation of a Section written application shall be made to the Academy, at a regular meeting, by not less than six active members.

On the approval of this application by the affirmative vote of two-thirds of the members present at the next regular meeting, the Section shall be established and the names of the petitioners shall be recorded on its minutes as its founders.

SEC. 3. Sections may increase the number of their members by election, but only members of the Academy shall be elected members of any of the Sections.

SEC. 4. The officers of each Section shall be a Chairman and a Secretary, who shall be elected by its members at the first meeting of the Section, and subsequently at the first meeting in January of each year.

SEC. 5. The collections and books of each Section are the common property of the Academy. Donations of books and

specimens made to or for any Section shall be received as donations to the Academy for the use of the Section.

SEC. 6. A report of the proceedings of each Section shall be submitted to the Academy at least once every month. Papers read before any Section with a view to publication by the Academy shall take the same course as papers read before the Academy.

SEC. 7. On all points not herein provided for, each Section shall be governed by the Constitution, By-Laws, and instructions of the Academy.

# BY-LAWS.

## I. REGULAR MEETINGS.

The regular meetings of the Academy shall be held on the first and third Monday evenings of every month, unless otherwise ordered by the Council.

## II. SPECIAL MEETINGS.

Special meetings may be called by the President at his discretion, and shall be called by him on the written request of three or more members.

## III. NOTICE OF MEETINGS.

The Recording Secretary shall send a notice of each meeting to every active member at least two days before such meeting.

## IV. QUORUM.

Seven members shall constitute a quorum, but four members shall constitute a legal meeting for reading of papers.

## V. ORDER OF BUSINESS.

The order of proceeding, at the regular meetings of the Academy, shall be as follows: —

1. Minutes of last meeting.
2. Report of the Council.
3. Reports of Committees.
4. Report of the Corresponding Secretary.
5. Donations to the Museum and Library.
6. Written Communications.
7. Oral Communications.
8. Deferred Business.
9. New Business.
10. Elections.
11. Proposals for Membership.
12. Adjournment.

### VI. CORRESPONDING SECRETARY.

It shall be the duty of the Corresponding Secretary to conduct the correspondence and report to the Academy.

### VII. TREASURER.

The Treasurer shall collect all moneys due the Academy; be custodian of all its funds, and pay such bills against the Academy as the Council shall approve. The Treasurer shall deposit the moneys and invest the funds of the Academy in its name and by and with the advice of the Council. Besides his annual report to the Academy, the Treasurer shall make such further reports and statements concerning the financial affairs of the Academy as the Council may from time to time require. Before entering upon his duties, the Treasurer shall give bond in such sum as may be required by the Council.

### VIII. LIBRARIAN.

The Librarian shall take charge of all books belonging to or deposited with the Academy, and shall be responsible for the same; he shall keep a catalogue thereof, in which the names of contributors shall be inscribed; he shall superintend the distribution of all the publications of the Academy.

### IX. COUNCIL.

The Council shall act as a publication committee; shall prepare a program for each meeting, and may make rules and regulations for their own guidance, not inconsistent with the Constitution and By-Laws.

### X. ELECTION OF OFFICERS.

A nominating committee of three active members who are not officers of the Academy shall be elected at the first regular meeting in December. This committee shall nominate

candidates for all the offices for the ensuing year, and report the nominations at the following meeting, when other nominations may be made by any active member. The Recording Secretary shall mail to every active member a list of the nominees for office, at least ten days preceding the annual meeting. The polls shall be closed at 6 p. m. on the day of the annual meeting, after which the nominating committee shall count the ballots and announce the results to the Academy. A plurality of the votes cast shall suffice to elect.

### XI. VACANCIES.

A vacancy in any office shall be filled by election conducted in the same manner as the annual election.

### XII. ELECTION OF MEMBERS.

A candidate for admission to the Academy shall be proposed by not less than two members at any regular meeting. The proposal must then be referred to the Council, and if upon examination they shall find the candidate to be eligible and worthy of membership, they shall order the question as to his admission to be submitted to the Academy by ballot. If there be five votes in the negative, the candidate shall be rejected, and shall not be again voted upon for twelve months after such rejection. But if the number of negative votes be less than five, the candidate shall be elected, but shall not be considered a member until he shall have paid the initiation fee and the annual dues for the current year. Any failure to pay the initiation fee and annual dues within thirty days after the candidate has been notified of his election, shall work a forfeiture of all rights under said election, if the Council shall so determine. No entry shall be made on the record of the rejection of any candidate.

### XIII. RESIGNATION OF MEMBERS.

Any member whose dues have been fully paid, may withdraw from the Academy by a written resignation. Non-pay-

ment of dues for one year or longer may be treated as equivalent to resignation; but before any member is dropped from the rolls for delinquency, he shall be entitled to not less than four weeks' notice.

### XIV. EXPULSION OF MEMBERS.

Upon the written request of five members, that, for cause stated, any member be expelled, the Council shall consider the matter, and if they deem it best, shall advise the member that his resignation will be accepted. He shall, however, have the right to demand and shall be given a copy of the charges against him, and shall have a reasonable time to present a written defense. The Council may then pass finally upon the matter, and if resignation has not been tendered, or a satisfactory defense made, may by an affirmative vote of four of their number expel the member, in which case they shall notify him and the Academy of their action, and his name shall be at once dropped from the list of members.

### XV. INITIATION FEE AND DUES.

Resident active members shall pay an initiation fee of five dollars, and annual dues of six dollars, payable at the beginning of each year. Non-resident active members shall pay an initiation fee of five dollars and annual dues of one-half the dues for resident active members, payable at the beginning of each year.

### XVI. HONORARY MEMBERS AND PATRONS.

Honorary members and Patrons shall be recommended by the Council, and elected by the unanimous vote of the members present at any regular meeting.

### XVII. PUBLICATIONS.

Patrons and all active members not in arrears shall be entitled to one copy of all the publications of the Academy

issued subsequent to their election. Authors of papers shall be entitled to twenty extra copies of their individual papers.

### XVII. SALE OF REAL ESTATE.

The property conveyed to The Academy of Science of St. Louis on the eighteenth day of March, 1903, by Edgar R. Hoadley and Lavinia L. Hoadley, as a gift from Mrs. Eliza McMillan and William N. McMillan, shall not be mortgaged or voluntarily incumbered by the Academy of Science; and the said property shall not be sold, except with the consent of two-thirds of the members of the Academy of Science, obtained by letter ballot, in such manner as may be prescribed by the Council, and, when sold, the proceeds of the sale or so much thereof as may be necessary, shall be used to provide a suitable location and building for the use of The Academy of Science of St. Louis.

### XIX. AUTHORITY.

On all points of order and procedure, not provided for in the Constitution and By-Laws, *Robert's Rules of Order* shall be the authority.

### XX. AMENDMENTS.

These By-Laws may be amended by a two-thirds vote of all the members present at any regular meeting, provided notice of the proposed amendment shall have been mailed to every member at least one week before the vote thereon is taken.

# ABSTRACT OF HISTORY.

## ORGANIZATION.

The Academy of Science of St. Louis was organized on the 10th of March, 1856, in the hall of the Board of Public Schools. Dr. George Engelmann was the first President.

## CHARTER.

On the 17th of January following, a charter incorporating the Academy was signed and approved, and this was accepted by vote of the Academy on the 9th of February, 1857.

## OBJECTS.

The act of incorporation declares the object of the Academy to be the advancement of science and the establishment in St. Louis of a museum and library for the illustration and study of its various branches, and provides that the members shall acquire no individual property in the real estate, cabinets, library, or other of its effects, their interest being usufructuary merely.

The constitution as adopted at the organization meeting and amended at various times subsequently, provides for holding meetings for the consideration and discussion of scientific subjects; taking measures to procure original papers upon such subjects; the publication of transactions; the establishment and maintenance of a cabinet of objects illustrative of the several departments of science, and a library of works relating to the same; and the establishment of relations with other scientific institutions. To encourage and promote special investigation in any branch of science, the formation of special sections under the charter is provided for.

## MEMBERSHIP.

Members are classified as active members, corresponding members, honorary members and patrons. Active membership is limited to persons interested in science, though they need not of necessity be engaged in scientific work, and they alone conduct the affairs of the Academy, under its constitution. Persons not living in the city or county of St. Louis who are disposed to further the objects of the Academy, by original researches, contributions of specimens, or otherwise, are eligible as corresponding members. Persons not living in the city or county of St. Louis are eligible as honorary members by virtue of their attainments in science. Any person conveying to the Academy the sum of one thousand dollars or its equivalent becomes eligible as a patron.

Under the by-laws, resident active members pay an initiation fee of five dollars and annual dues of six dollars. Non-resident active members pay the same initiation fee, but annual dues of three dollars only. Patrons, and honorary and corresponding members, are exempt from the payment of dues. Each patron and active member not in arrears is entitled to one copy of each publication of the Academy issued after his election.

Since the organization of the Academy, 982 persons have been elected to active membership, of whom, at the present time, 276 are carried on the list. Four patrons, Mr. Edwin Harrison, Mrs. Eliza McMillan, Mr. William Northrop McMillan and Mr. Henry W. Eliot, have been elected. The list of corresponding members (Vol. X., p. xii) includes 205 names, among which are the names of 103 persons known to be deceased.

The presence of a number of eminent scientists from all parts of the world at the International Congress during the World's Fair of 1904, was considered a suitable occasion for electing the following gentlemen as honorary members of the Academy, in recognition of their valuable services to science: Prof. Svante Arrhenius (Stockholm), Prof. Dr. Leopold

Bahlsen (Berlin), Prof. Dr. Ludwig Boltzmann (Vienna), Señor Alfredo Chavero (Mexico), Prof. Theodor Escherich (Vienna), Prof. Shibasaburo Kitasoto (Tokio), Geh. Ober Reg. R. Theodor Lewald (Berlin), Count Limburg-Stirum (Berlin), Prof. Henri Moissan (Paris), Geh. Rath Dr. Johann Orth (Berlin), Prof. Wilhelm Ostwald (Leipzig), Sir William Ramsay (London), Prof. Ernest Rutherford (Montreal), Prof. J. W. Van 't Hoff (Berlin), Geh. Rath Prof. Dr. Wilhelm Waldeyer (Berlin), Prof. Dr. Wassermann (Berlin), Geh. Rath Prof. Dr. L. Wittmack (Berlin), from all of which courteous letters of acceptance have been received.

## OFFICERS AND MANAGEMENT.

The officers, who are chosen from the active members, consist of a President, two Vice-Presidents, Recording and Corresponding Secretaries, Treasurer, Librarian, three Curators, and two Directors. The general business management of the Academy is vested in a Council composed of the President, the two Vice-Presidents, the Recording Secretary, the Treasurer, the Librarian and the two Directors.

The office of President has been filled by the following well-known citizens of St. Louis, nearly all of whom have been eminent in some line of scientific work: George Engelmann, Benjamin F. Shumard, Adolphus Wislizenus, Hiram A. Prout, John B. Johnson, James B. Eads, William T. Harris, Charles V. Riley, Francis E. Nipher, Henry S. Pritchett, John Green, Melvin L. Gray, Edmund A. Engler, Robert Moore, Henry W. Eliot, and Edwin Harrison.

## MEETINGS.

The regular meetings of the Academy are held at its building, 3817 Olive Street, at 8 o'clock, on the first and third Monday evenings of each month, a recess being taken between the meeting on the first Monday in June and the meeting on the third Monday in October. These meetings, to which interested persons are always welcome, are devoted in part to the reading of technical papers designed for publication in the

Academy's Transactions, and in part to the presentation of more popular abstracts of recent investigation or progress. From time to time public lectures, calculated to interest a larger audience, are provided for in some suitable hall.

The following dates for regular meetings for the year 1905 have been fixed by the Council: —

| Jan. | Feb. | Mar. | April. | May. | June. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|
| | 6 | 6 | 3 | 1 | 5 | | 6 | 4 |
| 16 | 20 | 20 | 17 | 15 | | 16 | 20 | 18 |

## LIBRARY.

After its organization, the Academy met in Pope's Medical College, where a creditable beginning had been made toward the formation of a museum and library, until May, 1869, when the building and museum were destroyed by fire, the library being saved. The library now contains 15,303 books and 12,361 pamphlets, and is open during certain hours of the day for consultation by members and persons engaged in scientific work.

## PUBLICATIONS AND EXCHANGES.

Fourteen thick octavo volumes of Transactions have been published since the organization of the Academy, and widely distributed. Two quarto publications have also been issued: one from the Archaeological section, being a contribution to the archaeology of Missouri, and the other a report of the observations made by the Washington University Eclipse Party of 1889. The Academy now stands in exchange relations with 584 institutions or organizations of aims similar to its own.

## MUSEUM.

After the loss of its first museum, in 1869, the Academy lacked adequate room for the arrangement of a public museum, and, although small museum accessions were received and cared for, its main effort of necessity was concentrated on the holding of meetings, the formation of a library, the publication of worthy scientific matter, and the maintenance of relations with other scientific bodies.

But now in possession of a suitable home, full attention can again be devoted to the museum, and the same is gradually growing.

# RECORD.

## From January 1, 1904, to December 31, 1904.

### Meeting of January 4, 1904.

The Academy of Science of St. Louis met in the Academy Building at 8:00 p. m., January 4, 1904; Vice-President Smith in the chair; nineteen persons present.

An oral report was submitted on the 189th meeting of the Council, showing that under authority the Treasurer had borrowed $1,750.00 for sixty days, at six per cent, on mortgage security owned by the Academy; that President Eliot had given to the Academy the sum of $5,000.00, of which nearly the entire amount had been expended in the renovation and improvement of the building, under his supervision, by authority of the Council; that $150.00 had been secured from the Angle School of Orthodontia, in return for the use of the Academy's rooms for a period of one month; that bills had been approved for payment to the amount of $477.60, of which $119.92 was for publication, $125.00 for a stereopticon, and $228.50 for electric wiring; that the Academy had lost two members through the death of Mr. Albert Thiele and the resignation of Mr. D. C. Ball; and that the names of A. V. Graf and Rudolph Schmitz were ordered submitted to ballot at the appropriate meeting of the Academy.

An oral report was submitted on the 190th meeting of the Council, showing that the Council unanimously recommended to the Academy the election of Mr. H. W. Eliot as a patron; and that bills amounting to $395.12 had been approved for payment.

The Vice-President presented the following address: * —

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* Transactions, Vol. XIII., Page XLV.

On the conclusion of the Vice-President's address, Professor Nipher called up the recommendation of the Council that Mr. Eliot be elected a patron, and in a few well chosen words moved a vote of thanks to Mr. Eliot for his continued interest in the Academy and his generous gift to it, and that he be elected a patron. The motion, being duly seconded, was unanimously carried.

On motion of Dr. Green, the recommendations contained in the Vice-President's address were referred to the Council, and their consideration was made a special order of business for the next meeting of the Academy.

The Treasurer presented the financial report and statement, with vouchers, which was submitted to an auditing committee consisting of Messrs. Engler, Green and Ewing, on whose report as to its correctness it was approved.*

The Librarian presented the accompanying report, which was received.†

On behalf of the nominating committee, Mr. Krall presented the appended report, which was received, and the following officers were declared elected for the year 1904: —

| | |
|---|---|
| President | W. K. Bixby. |
| First Vice-President | Wm. Trelease. |
| Second Vice-President | Adolf Alt. |
| Recording Secretary | Ernest P. Olshausen. |
| Corresponding Secretary | August Hunicke. |
| Treasurer | Enno Sander. |
| Librarian | G. Hambach. |
| Curators | G. Hambach, |
| | Julius Hurter, |
| | Frank Schwarz. |
| Directors | F. E. Nipher. |
| | Jos. Spiegelhalter. |

The Secretary stated that on learning that his name had been placed in nomination for the Presidency of the Acad-

* Transactions, Vol. XIII., Page XLVII.

† Transactions, Vol. XIII., Page XLVIII.

emy, Mr. Bixby had signified his wish to have it withdrawn, but, this being impossible, he had presented his resignation as President, which on motion was accepted.

In accordance with Articles X and XI of the By-Laws, it was moved that a nominating committee of three, consisting of Messrs. Krall, Barck and Widmann, be elected, to present at the next meeting a new nomination for the Presidency of the Academy; and this motion was unanimously carried.

The following persons were elected to active membership: August V. Graf, Rudolph Schmitz, both of St. Louis.

Dr. Green stated that he was privileged, on behalf of a few members of the Academy, to present, in commemoration of its removal into its new home, a suitable chair and table for the use of the presiding officer; and on motion this gift was accepted and the thanks of the Academy tendered to the gentlemen who had made it.

JANUARY 18, 1904.

Vice-President Trelease in the chair; twelve persons present.

The nominating committee reported that they had nominated for President Mr. *Edwin Harrison.*

No other nomination being made, the printing of letter-ballots was ordered.

The following three papers were presented by title and referred to the Council: —

By *Mary J. Klem*, "A revision of the Paleozoic Palaeëchinoidea, with Synopsis of all known Species."

By *Frank C. Baker*, "The Molluscan Fauna of the Dells of Wisconsin;" "Notes on Planorbia Truncatus Miles."

The Treasurer, Dr. Enno Sander, reported, that in response to his request for voluntary contributions by members, he had received $49.00.

FEBRUARY 1, 1904.

Dr. A. Alt presiding; fourteen persons present.

The nominating committee reported the election of Mr. Edward Harrison as President of the Academy.

Prof. F. E. Nipher made some informal remarks on some properties of Radium, as compared with certain other bodies, indicating, that much of the mystery, now connected with radium, will probably soon be cleared, as we get better acquainted with it, finding it subject probably to well-known physical laws. His remarks were followed by a discussion.

The Treasurer reported further voluntary contributions, amounting to a total of $248.00.

### February 15, 1904.

Dr. Wm. Trelease presiding; twenty-eight persons present.

Rev. Martin S. Brennan delivered a popular lecture on the "Nebular Hypothesis," illustrating same with lantern views. He explained the theory of La Place, according to which the heavenly bodies were formed by a condensation of gases into nebular masses, these in turn condensing farther by the force of gravity, the interior increasing in pressure, centrifugal motion and heat, while the peripheric motion decreased and gradually cooled the mass, until it formed a crust, growing thicker in time; this crust being at first surrounded chiefly by carbon-dioxide gases, soon allowing the existence of plant life, later followed by animal life. From this he deduced the five geological eras, corresponding with the ages of paleontology.

Mr. Nipher remarked, that he had applied the equations for gaseous nebulae, which had been deduced in his paper on the Law of Contraction of Gaseous Nebulae, to the case of our own planetary system. Introducing an integration constant into the pressure formula, the pressure, — and as consequence the temperature, — can be made zero at any radius from the center. He had given the constant a value, which made the mass of the nebula equal to that of the entire solar system. When the nebula has reached such a stage, that the mass external to Neptune's present orbit, is equal to Neptune's mass, the density at Neptune's orbit will be $1.93 \times 10^{-15}$ grammes per cc., and the pressure will be $1.49 \times 10^{-10}$ atmosphere. The outer limit of the nebula will be about half a

million miles further out, the temperature being zero at the outer limit. This means, that molecular motion will not there exist.

The forces there acting will be gravitation, and the repelling action of light waves from the central nucleus. The entire mass of Neptune will exist in a space far more highly rarified than any Crooks tube vacuum. It is of course possible for such nebulae to exist, but it certainly is impossible to believe, that such a nebula can throw off a system of planetary bodies. The greater part of our solar nebula must have existed as a solid meteoric matter, with a temperature approaching absolute zero. Only the central part, which is now represented by the sun, was largely gaseous, and at a high temperature.

Professor Nipher made the following remarks on Discontinuities in the evolution of the Trotting Horse: —

About twenty years ago the writer deduced an equation representing the relation between the record speed of the trotting horse and the time, estimated from any assumed date. This equation was not obtained from the actually observed times when the record had been broken. It took no account of individual cases.

The date when any given speed, as say 2:30, originated, was determined by finding the number of horses each year, capable of making that speed or better. At some date the first horse of this class would appear. Each successive year, the number of horses of this class increases. The law of such increase can easily be determined by graphical or mathematical methods. In this way the date when the number of horses of this class was one, can be determined, by means of this curve of increase.

Knowing the dates for the origin of each speed, the relation was shown to be a logarithmic one. The equation was published giving the speed for any given date. Recently this curve was plotted, from 1840 to date, and the performance of every horse who has broken the record since 1845 was put on the diagram. A very interesting fact was at once observed. The increase in speed is not continuous, but proceeds by sudden and rapid changes, separated from each other by intervals of no change. The horse will be behind the speed computed

from the equation, and some horse, usually in rivalry with another, will perhaps in a single year, put the horse ahead of this computed speed.

In 1853 the horse was about three seconds behind the computed speed. In that year Highland Maid advanced one second, and from 1856 to 1859 Flora Temple had carried the record ahead six and a quarter seconds more. This placed the horse 2.3 seconds ahead of the computed speed.

In 1867 Dexter found the horse again about 1.25 behind, and in two races during that summer, placed the horse 1.25 ahead of the computed speed. In 1871 Goldsmith Maid found the horse behind nearly a second, and by 1874 put the horse ahead of the computed speed by about 2.25 seconds. When Rarus appeared in 1878, the horse was again nearly a second behind, and Rarus, St. Julian, Jay Eye See were in rivalry with Maud S. during seven years. They not only kept the record from falling still further behind, but in 1885 Maud S. finally sent the record ahead of the computed speed about 1.5 seconds.

In 1891 Sunol again found the horse slightly behind the computed speed and advanced him half a second. During the next year Nancy Hanks appeared and sent the horse ahead again. During this year appeared also a marked discontinuity in the evolution of the running gear. Improvements had been constantly made in the sulky during all of the time from 1840 to 1892. At this latter date the modern sulky with pneumatic tire, 28-inch wheel and ball bearings was first used. With this running gear Nancy Hanks placed the horse a little over three seconds ahead of the prediction, and in 1894 Alix lowered this record a quarter of a second more.

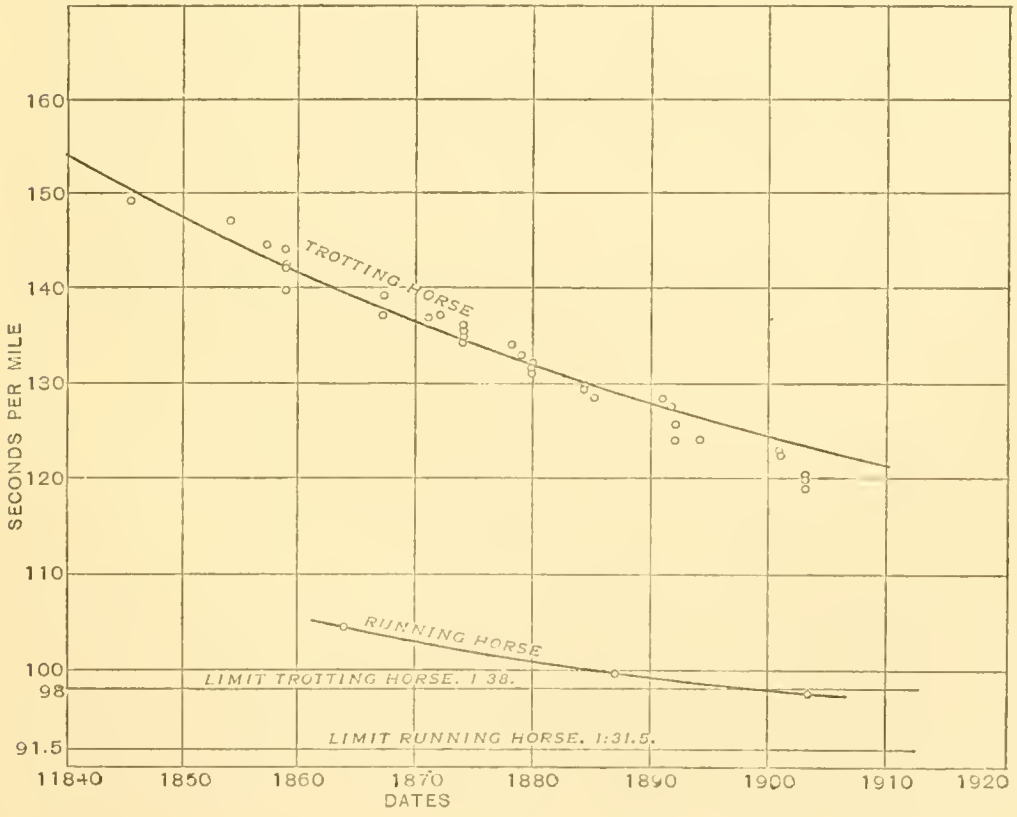
Six years later the present generation of trotters began. The Abbott lowered the time of Alix by half a second, and then began the contest between Crescens and Lou Dillon, which has resulted in putting the trotting horse 4.5 seconds ahead of the predicted speed.

These successive generations of horses have changed the record as follows: —

| | | | |
|---|---|---|---|
| Flora Temple.... | 7.25 | Maud S..... | 5.25 |
| Dexter..... | 2.50 | Nancy Hanks.... | 5.0 |
| Goldsmith Maid.. | 3.25 | Lou Dillon ..... | 5.25 |

In this exhibit the name of the most prominent horse in the generation has been selected for designating the several generations. Since the time of the advent of the bicycle wheel, the surging advances of speed which characterize a generation, have continued, as they were before, but the horse has not fallen behind the predicted speed. In time the sudden advance due to this radical improvement in the sulky, will probably be taken up again, and the horse will gradually come back into line with what was shown in the earlier generations. I do not think there is any evidence that the final speed of the horse will differ materially from what was predicted twenty years ago.

It may be said in closing that when the earlier paper was published, in 1883, there were many who scouted the idea that the trotting horse would ever trot a mile in 98 seconds. It has happened that some of these same persons have now thought it proper to poke fun at the writer because the horse is now slightly further in advance of the prediction than ever before. A diagram is here presented which shows the dis-



continuities in evolution of the trotting horse. If the prediction were to be made now on the basis of what is now known, no change would be made. The same diagram represents the performance of the running horse, by the lower curve. His final speed will be about 6.5 seconds per mile better than that of the trotting horse, or 1:31.5 (91.5 seconds per mile).

Since the above communication was made, the three last records shown on the diagram have been ruled out. They were made with a wind-shield in front of the horse. The present record stands at 121.25 or 2:01¼.

### March 7, 1904.

Attendance, eighteen.

President Edwin Harrison in the chair.

Dr. C. A. Snodgrass, City Bacteriologist and Pathologist, read a paper on the subject: "Bacteria and their Work," illustrated with drawings and cultures. He gave a clear conception of the place occupied by bacteria in the living world, and the important work they do. He emphasized the fact, that bacteria must not be confounded with disease. He discussed the distribution of bacteria, changes in bacterial flora in milk supplies; the bacteria of the Illinois, Missouri and Mississippi rivers; symbiosis; immunity; biological factors, that affect bacteria; the relation of human and bovine tuberculosis; and various methods by which infection occurs.

### March 21, 1904.

Attendance, eighteen.

President Edwin Harrison in the chair.

Professor Francis E. Nipher presented a paper on "Primitive Conditions in the Solar Nebula," * as a continuation to other papers presented previously.

Prof. W. L. Eickenberry delivered a lecture on the "Principles of Ecology and Development of Plant Societies."

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* Transactions, Vol. XIV., No. 4.

He showed, that the science of botany had been greatly advanced by the study of plant-ecology or plant sociology, *i. e.* by the study of plants in their external relations to each other, and the adjustment of plants and their organs to their physical surroundings. Formerly taxonomy or the determination of the position of plants in a scheme of classification, was the aim of all students and teachers. Now the study of botany is pursued on a broader scale, plants being studied as living things, which are not scattered at haphazard over the globe, but are organized into definite communities, determined by the conditions, under which certain plants can live. Ecology, since it considers plants and their environments, takes the student directly into the field, instead of confining him to herbarium specimens. Systematic botany, while very essential, should always be made one of *means*, and not the final end of botanical study.

By a series of lantern slides, Prof. Eickenberry showed the transition from a pond-society to a swamp-forest, beginning with a lily-pond with sedges at the margin of the water. Then, as the pond loses its water, the sedges and swamp-grasses crowd in; this swamp-moor being followed by shrubs, and finally by a swamp-forest, such as tamarack, pine and hemlock.

He also traced the development of plant societies, adapted to dry air and soil, various plants, such as lichens, mosses and small crevice plants being able to live upon bare rocks. As these exposed rocks are weathered away, the crevice plants become larger, and seeds of small plants find lodgment, until, the fissures increasing in size, and more soil being formed, shrubs and finally trees root there, resulting ultimately in a forest.

April 4, 1904.

Attendance, fifty.

President Edwin Harrison in the chair.

The Treasurer reported further progress in voluntary contributions. Previously reported, $228.00. Additional receipts, $79.00.

Mr. George M. Wright was elected an active member.

Dr. C. Barck read the paper of the evening, on "The History of Spectacles." He divided the subject into two parts, the development of the industrial art, and the evolution of the scientific selection.

In regard to the former, it is an open question, whether the Chinese invented glasses prior to the Europeans. Of the ancient nations of western Asia, we possess only one relic, namely a convex lens of rock crystal which was discovered among the ruins of old Nineveh by Sir Layard. To the Egyptians, Greeks and Romans glasses were unknown. The latter assertion does not agree with the common opinion, as expressed in the belief, that Nero was near-sighted and used glasses. But this is due to a misinterpretation of a passage of Pliny, as proven at length by the reader of the paper. During the first twelve centuries of the Christian era there is no mention of spectacles; they were invented at the end of the thirteenth century by two Italians, Armati and Spina, either independently or conjointly. This is proven by a number of documents. The essayist then dwelt upon the gradual spread of their use, and the improvement of the frames and lenses. At first only convex lenses were used, concave ones being employed about two centuries afterwards. Cylindrical lenses for the correction of astigmatism, which had been discovered by Thomas Young in 1801, were devised by the astronomer Airy in 1827. Bifocals were invented and first used by Benjamin Franklin, 1785.

As to the selection of the appropriate lenses, this was at first done by the peddlers who sold them. Physicians for a long time paid no attention to it. Even after the epochal work of the astronomer Kepler had opened a new era in optics by demonstrating the physiology of the act of vision, 1604, physicians maintained their reserved attitude, and considered it below the dignity of their profession to have anything to do with the selection of glasses. It was only in the middle of the last century that the change took place. This was due mainly to the labors of Helmholtz and Donders, who laid the foundation for the adjustment of lenses accord-

ing to mathematical and optical principles. The invention of the ophthalmoscope, by which the refraction can be determined objectively, of the ophthalmometer, which assures the astigmatism of the cornea, and the introduction of remedies, by which the accommodation can be paralyzed, followed in rapid succession. By means of these instruments and methods of precision, the medical adviser is governed by well-established laws in the selection of spectacles, and this now belongs to the domain of science.

The lecture was illustrated by a number of copies of old paintings and by drawings.

April 18, 1904.

Attendance, twenty-five.

President Edwin Harrison in the chair.

The following were elected active members of the Academy: Dr. A. Siebert, Geo. H. Zollmann, Wm. F. Boyle.

The lecture of the evening was delivered by Dr. Coulter, being: "Typical Swamp Areas and their characteristic Plants." The same was illustrated with lantern slides.

May 2, 1904.

Attendance, twenty-two.

President Edwin Harrison in the chair.

A paper of Mr. B. F. Bush, on "The Genus Othake Rafinesque" was presented by title by Prof. W. Trelease, and referred to the Council for publication.

Mr. Charles M. Rice was elected an active member.

The lecture of the evening was delivered by Prof. Dr. L. Wittmack of the Berlin University, being a treatise on "Our Knowledge of Prehistoric Seeds." He described the seeds examined by him, from the pyramids of Egypt, from the ruins of Pompeii and Herculaneum, from the mounds of North America, and the excavations at Anco, in Peru. The seeds from Egypt and Pompeii were chiefly: wheat, barley, coreander, a large bean, lentils, olives, dates, plums, etc.; but

no oranges or lemons, which must have been introduced into Italy at a later date, probably by the Moors.

Bread taken from the pyramids of Egypt still showed the typical cell-structure of the barley-grains, and gave the well-known starch-reaction, when treated with iodine, — after a lapse of 4500 years.

In the American mounds Dr. Wittmack found corn, peanuts, apple-seeds, pumpkin-seeds, garden beans, etc. Europe had always been considered the home of the garden-bean; but Dr. Wittmack proved conclusively, that the garden-bean originated in America. The New World is also the home of corn, cotton, tobacco, potato, sweet potato, tomato, peanuts, pumpkin, and squash, all of which have become articles of economic importance in Europe as well as in America.

### May 16, 1904.

Attendance, twenty-four.

President Edwin Harrison in the chair.

The following were elected active members: W. J. McBride, Howard S. Reed, Herbert W. Wolff.

Prof. W J McGee delivered a lecture on "Types of Mankind at the Exposition."

### June 6, 1904.

Attendance, thirty-two.

Dr. A. Alt, presiding.

President Edwin Harrison presented to the Academy a portrait of Prof. Louis Agassiz.

Mr. Henry A. Huston was elected an active member.

Dr. A. Siebert delivered a lecture on "Liquid Light."

Mr. Frederick Braun of New York exhibited a collection of fossils (crinoids and trilobites).

### October 17, 1904.

Attendance, twenty-eight.

Dr. A. Alt presiding.

Mr. Frank Schwarz was offered a vote of thanks for preparing a number of skulls and heads for exhibition and decoration in the Academy's museum.

Mr. R. D. Douglas of South Africa exhibited a number of specimens of butterflies and beetles and photographic scenes.

Dr. J. Arthur Harris delivered a lecture on "The Nature and Function of the Color of Flowers" in relation to their attraction of insects in search of nectar.

The following scientists were elected honorary members in recognition of their service to science: —

Prof. Dr. A. Wassermann, of University of Berlin, Germany.

Prof. Dr. L. Wittmack, University of Berlin, Germany.

Geheimr. Prof. Dr. Johann Orth, of University of Berlin, Germany.

Geheimr. Prof. Dr. Wilhelm Waldeyer, of University of Berlin, Germany.

Prof. Dr. Leopold Bahlsen, of University of Berlin, Germany.

Graf Dr. Limburg-Stirum, of Berlin, Germany.

Geheim. Ober. Reg. Rath Theodor Lewald, of Berlin, Germany.

Sir William Ramsay, Royal Institute, London, England.

Prof. Ernest Rutherford, McGill University, Montreal, Canada.

Prof. Henri Moissan, Sorbonne, Paris, France.

Prof. J. W. Van 't Hoff, University of Berlin, Germany.

Señor Alfredo Chavero, National Museum, Mexico.

Prof. Shibasaburo Kitasato, University of Tokio, Japan.

Prof. Theodor Escherich, University of Vienna, Austria.

Prof. Svante Arrhenius, University of Stockholm, Sweden.

Prof. Ludwig Boltzmann, University of Vienna, Austria.

Prof. Wilhelm Ostwald, University of Leipzig, Germany.

## November 7, 1904.

Attendance, twenty-eight.

Dr. A. Alt presiding.

The following were elected active members: Waldemar H. A. Koch, of Columbia, Mo., Walter Bernays, City Chemist.

Prof. F. E. Nipher gave a Popular Discussion of some present "Problems in Physics."

He dwelt principally on the present conception of the nebular hypothesis and its bearing on the evolution of the universe, in connection with the influence upon and of electricity. He presented some interesting photographic negatives, gathered during his scientific researches.

He also entered into an explanation and comparison of galvanic, static, and mechanical electricity. His deductions from a careful study of the phenomena and conclusions based thereon, led to the assumption that the sun is the basis of all creation, and that the planets are but particles emanating from that center at various epochs.

And he expressed the opinion, that when the art of overcoming inertia is once understood, all mechanical problems will have been near solution.

### November 21, 1904.

Attendance, twenty-five.

Dr. Wm. Trelease presiding.

A paper by Mr. B. F. Bush, on "The Texas Tradescantias" * was presented by title and referred to the Council for publication.

Mr. J. E. Petavel, of the British Royal Commission, delivered an interesting lecture on "The Ultimate Limit of Low Temperature" illustrating same with numerous experiments with Liquid Air.

### December 5, 1904.

Attendance, one hundred and twenty-five.

Dr. Wm. Trelease presiding.

In accordance with the constitution and by-laws, the fol-

* Transactions Vol. XIV, No. 7.

lowing members were elected a committee to nominate a ticket for the annual election: —

Prof. John H. Kinealy.
Dr. Chas. D. Stevens.
Dr. H. M. Whelpley.

Mr. J. W. Erwin, of San Francisco, delivered an interesting lecture on "The Wonders and Glories of California," illustrated with numerous stereopticon views, showing the beauties of the forests, the wonderful results of irrigation, ostrich farming, fruit growing, the grandeur of the sea-coast, etc.

DECEMBER 19, 1904.

Attendance, twenty-five.

Dr. A. Alt presiding.

The Secretary reported the receipt of letters of thanks for their election as honorary members of the Academy, from the scientists named in the meeting of October 17th.

The nominating committee reported the following ballot for the annual election, which was ordered printed and mailed to the members: —

| | |
|---|---|
| President | Dr. Adolph Alt. |
| First Vice-President | Wm. Trelease. |
| Second Vice-President | Dr. Joseph Spiegelhalter. |
| Recording Secretary | Ernest P. Olshausen. |
| Corresponding Secretary | August Hunicke. |
| Treasurer | Enno Sander. |
| Librarian | G. Hambach. |
| Curators | G. Hambach. |
| | Frank Schwarz. |
| | Julius Hurter. |
| Directors | F. E. Nipher. |
| | Otto Widmann. |

The following were elected active members: Jacob Walter, Benjamin Altheimer.

Dr. Walter G. Kirchner delivered an interesting lecture on "Bacteriological Examination of River Water," based chiefly

on his observations, while examining the water of the Mississippi river near St. Louis, to test the influence of the Chicago canal upon the water supply of St. Louis. He explained the importance of carefully collecting the samples for examination purposes, and their careful preservation in a condition and temperature as near as possible, as when taken, which frequently requires keeping them on ice to prevent further development, increase or decrease of the number of bacteria contained in the sample, thereby securing perfect results. He also exhibited the apparatus and methods used in such examinations. He also showed by black-board drawings and charts how the number of bacteria varies at different points of the same body of water, according to their location near cities or sewage outlets, and other conditions and influences.

Professor F. E. Nipher made some remarks on the methods used for measuring wind-velocities, to determine the pressure, which latter is generally adopted as being equal to the square of the velocity. But he feared, that the old method by means of pressure boards gives no satisfactory measure for determining the pressure of a heavy wind on high buildings; therefore other methods were desirable for this object.

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## Reports of Officers for the Year 1904.

The Treasurer reported as follows: —

RECEIPTS.

| | | |
|---|---|---|
| Balance for 1903 | $ 563 43 | |
| Membership dues | 1,444 15 | |
| Voluntary contributions | 344 00 | |
| Rent from building | 355 00 | |
| Notes discount | 3,750 00 | |
| Interest | 278 49 | |
| Capital released | 3,000 00 | |
| | | $9,735 07 |

EXPENDITURES.

| | | |
|---|---|---|
| Publication of Transactions | $,486 57 | |
| General printing | 174 60 | |
| Library | 118 52 | |
| Improvements to property | 175 63 | |
| Service | 1,394 50 | |
| Sundry expenses | 459 27 | |
| Notes discounted and premiums paid | 5,544 65 | |
| Balance | 1,381 33 | |
| | | $9,735 07 |

INVENTORY.

| | | |
|---|---|---|
| Real estate, 3817 Olive | $25,000 00 | |
| Improvements 1903 | 5,929 47 | |
| Improvements 1904 | 173 63 | |
| Mortgage | 3,500 00 | |
| | | $34,603 10 |

## *Report of the Librarian.*

It is with great pleasure and satisfaction, that I am able to report that the first year of the Academy's occupation of its own home has witnessed the re-establishment of its museum of natural history objects. The few articles of value saved from the fire, which the Academy suffered some years ago, together with the fine Yandell Collection of fossils, purchased four years ago, the beautiful collection of butterflies, mostly tropical, presented to the Academy by subscription through the efforts of the late Mrs. W. L. Bouton, a collection of meteorites and of several hundred specimens of pottery from the mounds of southern Missouri, and of forty human crania from the same district, have been placed on exhibition in the museum.

During the year Mr. Frank Schwarz, of the Board of Curators, mounted two skulls of the Colorado Mountain Sheep and two of the Buffalo, belonging to the Academy.

Mr. Edwin Harrison, President of the Academy, presented a portrait of the famous naturalist, Prof. Louis Agassiz, taken when the Professor was winning fame for his great scientific achievements.

Mr. Richard Douglas of South Africa donated to the museum a skull of an African Lioness, a shark's skull and a specimen of the queen of the white ant of South Africa.

During the year just closed the museum of the Academy has been enriched by the acquisition of some very valuable specimens from the Department of Mines and Metallurgy at the World's Fair. Among the liberal donators may be mentioned Mr. Whitaker, in charge of the Utah Exhibit, from whom fine specimens of carnolite, cinnabar, gilsonite, realgar and olivinite were obtained; Mr. Chas. N. Gould of Oklahoma, who presented some beautiful specimens of pseudomorphous crystals of sandstone after aragonite, some gypsum, rose quartz and calcspar; Mr. C. H. Pilcher of South Dakota, who donated fine lead, tin and copper ores and rose quartz; Mr. Francis B. Laney of North Carolina, who gave us flexible sandstone and nickel ores from his State; Mr. Harry E. Crain, who contributed hematite, malachite, native sulphur, silicified wood, moss agate and calcosite from Wyoming; Mr. Frank C. Friedman of Arizona, from whom glauberite, argentite and wulfenite beside copper and silver ores were procured; Mr. Ladd of Missouri, who presented specimens of galena, sphalerite, dolomite and calcspar; Capt. Brown of Arkansas, whose contribution consisted of good specimens of variscite, wavellite, smithsonite and calamine from his State. From the director of the New Mexico Exhibit fine silver and copper ores, and from the Nevada commissioner cuperite, proustite and silver-bearing lead ores from their respective States were obtained.

To properly care for these precious minerals four cases were purchased at the Fair.

While the acquisitions of the year have been most gratifying still we have at present only a nucleus to the museum we hope to establish at the Academy. It is the intention of the Board of Curators to form collections in the various branches of natural science, especially as represented in our own State, which shall be of benefit and interest to the public and to the educational institutions of the city. One of our first attempts

shall be to procure as complete a collection as possible of the minerals of Missouri and of the insects about St. Louis.

Now that we are in our own home, with the prospect of a fire-proof addition, we feel that we are in a position to renew our activities toward re-establishing the fine museum we lost, and earnestly desire the co-operation of all the members and of those interested in seeing the establishment of a natural history museum worthy of the name in St. Louis, in procuring objects of interest to students of nature, especially such objects as will make known to our citizens the vast resources and wealth of their own State. It is our aim to have the Academy looked upon by the public at large as a place where information may be sought on any scientific subject.

The collections of the Academy are being placed as quickly as possible and the public is most cordially invited to visit the museum, which is open every day except Sunday.

During the past year the publications of the Academy were sent to 162 domestic and to 422 foreign societies. Nine societies were added to the exchange list during the year and two resigned, making an increase of seven. We received publications in exchange from 76 domestic and 218 foreign societies.

| | | | |
|---|---|---|---|
| Received during the year — | | | |
| in exchange | books | 385 | |
| | pamphlets | 638 | |
| by donation | books | 25 | |
| | pamphlets | 60 | |
| | Total | | 1108 Nos. |

Dr. Enno Sander donated a number of medical journals and Mr. Edwin Harrison six pamphlets and two books of publications of the Peabody Museum of American Archaeology and Ethnology.

Thirty-nine volumes were bound for $15.60.

| | | |
|---|---|---|
| Expenses of the department for postage, express charges, binding, etc | | $213 32 |
| Cash received from sale of Transactions | $48 82 | |
| Cash received from Treasurer | 65 00 | 113 82 |
| Balance due | | $99 50 |

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Transactions of The Academy of Science of St. Louis.

VOL. XIV. No. 1.

# A REVISION OF THE PALAEOZOIC PALAEECHINOIDEA, WITH A SYNOPSIS OF ALL KNOWN SPECIES.

MARY J. KLEM.

*Issued May 5, 1904.*

MAY 30 1904

# A REVISION OF THE PALAEOZOIC PALAEËCHINOIDEA, WITH A SYNOPSIS OF ALL KNOWN SPECIES.*

Mary J. Klem.

Among the Echinodermata, the Palaeozoic Echini present a most fertile field for the study of variations and abnormal development, — features which are common, however, throughout the sub-kingdom. Having had at my command for study a very large and excellent collection, I wish to offer a few suggestions as to the probable development of these interesting fossils.

I take this opportunity to express my sincere thanks to my dear friend and teacher, Dr. Hambach, professor at Washington University, for the use of his valuable collection and library, as well as for the interest he has taken in the preparation of this paper. All the drawings submitted were made from specimens in the Doctor's collection, and most of the works quoted are in his library.

Before entering upon the detailed study of the development and arrangement of the different parts, it may be well to note the classification of fossil Echini. All the Palaeozoic Echini belong to the class *Cidaridae*, and differ from the Mesozoic, Cenozoic and living species, in having never less than *four* rows of plates in each interambulacrum, with the exception of one order, *Bothriocidaroida*. They may be conveniently divided into three orders: (1) *Cystocidaroida* with four rows of plates in the ambulacrum and numerous rows in the interambulacrum; (2) *Bothriocidaroida* with two rows of plates in each ambulacrum and one row in each interambulacrum; (3) *Perischoëchinoida* with never less than two rows in each ambulacral area and never less than four rows in each interambulacral area.

In the following discussion I shall confine my attention chiefly to the *Melonitidae*, a family of the *Perischoëchinoida*.

* Presented by title to The Academy of Science of St. Louis, Jan., 1904.

After a very careful study of the large collection of Dr. Hambach, which contains the choicest specimens to be found anywhere in that particular branch, and of the Washington University collection, among which is a slab with eighty-five Melonites on it, I have deduced the following facts concerning the development and growth of this family. In the embryonic state a calcareous particle was deposited as the nucleus of calcification of each plate of the test. As the test expanded successive rings of calcareous matter were deposited. While increasing laterally by the progressive calcification of the individual plates, the longitudinal diameter was lengthened by the addition of new plates between the genital and ocular plates and the already existing plates. That the lateral expansion took place by the deposition of rings of calcareous substance to the edges of each individual plate, is brought out very clearly in weathered specimens, well defined lines marking the limits of the different areas. Such specimens are figured on Pls. V. and VI., figs. 9 and 10, where the older deposit is shaded, while the more recent is left unshaded.

Turning our attention to the development and structure of the interambulacral areas, we find Jackson and Jaggar in their paper on "Studies of Melonites multipora," * making the following statement: "The interambulacra of the adult, when perfect, consist of two plates at the ventral termination, as shown in three areas, A, C and I, of plate 2, figure 2." In my researches, I find that ventrally the interambulacra always terminate in three plates, when the specimen is perfect. In all the specimens with the teeth in place, this is invariably the case as may be readily seen from figs. 6, 8, 12 and 13. This feature is shown most admirably by fig. 8, pl. IV., from which specimen the drawing of the teeth (fig. 8 f, pl. IV.) was made. The specimen shows plainly how the sides of the terminating plates come close up to the jaws, making it impossible for any plates to have dropped out. Besides the specimens I have mentioned, I examined a large amount of material, only to find that the aforesaid is always the case when the specimens

* Bull. Geol. Soc. Amer., vol. 7, p. 142.

are perfect. The statement of Jackson and Jaggar that areas showing three plates ventrally should be considered incomplete ventrally, and that, "when well preserved show at the oral termination angles for the articulation of the lower most missing row," * is easily refuted. When examining perfect specimens, I have always found that immediately below the three lowest plates were the teeth, thus precluding any possibility of any plates having fallen out.

The same gentlemen assert further that the lower row of plates does not really represent the initial plate, but that it was a single plate, which, by the encroachment of the enlarged actinostome, was gradually reabsorbed. As conclusive evidence they make the following statement: † "In a specimen of Melonites multiporus in Yale University Museum (diamond number 157, specimen C) we find an important feature bearing on the above consideration. In this specimen (plate 3, fig. 10) the two ventral plates have each an angle toward the median line, and these together with the straight edges of the bottom enclose a triangular space which doubtless contained the single initial plate, as in a similar stage of Strongylocentrotus. This specimen of Melonites does not actually show the initial single plate, and obviously in its peculiar position it would easily drop out after the death of the individual or in the processes of fossilization. To our minds the angles for its reception are almost as strong evidence as the plate itself."

I see no proof from the figure that the plates numbered 1 and 2 were the terminating plates and no reason to assume that the initial plate was triangular. Taking the drawing as given on pl. 3, fig. 10, we can increase the number of plates ad libitum, simply by completing the hexagons. Why should we assume that the initial plate was triangular, when perfect specimens show clearly that there were three and that they were pentagonal or hexagonal? Furthermore, if resorption took place (which I doubt very much) by what law of nature could the plates twist themselves from the

* Bull. Geol. Soc. Amer., vol. 7, p. 143.

† Bull. Geol. Soc. Amer., vol. 7, p. 144.

position indicated in fig. 11, pl. 3, to that shown in fig. 10, pl 3? * It is plain that the form of the plates was constant throughout the existence of the individual and that growth took place by the enlargement of the individual plates and by the addition of plates between the apical disk and the already existing plates.

The next point, which may properly be discussed at this stage, is the method of plate arrangement and the introduction of new columns. No adequate rule can be laid down as to the normal arrangement of plates and the interval between the introduction of new columns, as it is almost impossible to find two specimens, or even two fields of the same specimen, with the identical plate arrangement. A different rate of development in two adjacent areas is not an uncommon thing, being the rule rather than the exception. As an example take the fields of fig. 13, pl. 6, which is a perfect specimen. In section (a) the first column is introduced in the third row, in section (b) in the sixth and in (c) in the fifth row. The second column begins in (a) in the sixth, in (b) in the ninth and in (c) in the eighth row. The third column starts in (a) in the tenth, in (b) in the ninth and in (c) in the twelfth row. The fourth column is introduced in the thirteenth row in (a), in the twelfth in (b) and (c). In Fig. 8, Pl. IV the first column begins in the second row in (a), (b), (c), (e) and in the fifth in (d). The second column starts in the sixth row in (a), (b), (e), and (c) and in the fifth in (d). The third column is introduced in the ninth row in (a), (b), (e) and in the sixth in (c) and (d). The fourth column begins in (a) and (b) in the twelfth row, in (c) in the sixth, in (d) in the ninth and in (e) in the thirteenth row. The fifth column is introduced in the fifteenth row in (a), (b) and (e), in the ninth in (c) and in the twelfth row in (d). The sixth column has its beginning in the eighteenth row in (a), in the nineteenth in (b) and (e), in the eleventh in (c) and in the fourteenth in (d). Other specimens showing this feature plainly are figured on

* Jackson and Jaggar. Bull. Geol. Soc. Amer., vol. 7.

Pl. I., Figs. 2 and 3, Pl. II., Figs. 4 and 5, and Pl. III., Fig. 6.

Jackson and Jaggar in their article on Melonites lay down as a law that "newly added columns normally alternate to left and right as introduced, even numbered columns typically appearing on the right of odd ones."* While this rule may apply to some isolated and imperfect specimens, the contrary becomes quite evident by examining a large and complete collection of perfect fossils, as in Fig. 4, Pl. II., where the third column begins to the right of the second column in (b) and (c); in Fig. 3 b where the second column appears to the left of the first, and the fourth to the left of the third. Other exceptions to the rule laid down by the aforesaid authors appear in Figs. 2 b, c, d, Figs. 5 c, Figs. 6 c, d, e, Figs. 8 a, b, c, d, e, Figs. 10 a, b, c, Figs. 12 a, b, and Figs. 13 a, b, c. If the rule given by Jackson and Jaggar were applicable in all case, one should be able to determine, from a fragment, whether the column introduced is an odd or an even numbered one by its position to the left or right of the median line. But, since we find in specimens with all the plates intact that columns very often fall to the opposite side from the one established by Jackson and Jaggar, it is evident that this rule is of no value in describing specimens. In Fig. 6 the second column introduced falls to the right in only two areas, the third to the left of the second in only two fields; the fourth to the right of the third in only three areas and the fifth to the left of the fourth in only three areas.

Another feature, which will not stand a critical test, is the suppositon of the above mentioned authors, that new columns are always introduced by a pentagonal plate with the apex pointing ventrally or toward the oral area. This rule is subject to many variations, columns being introduced frequently by hexagonal or heptagonal plates and occasionally by square plates. In Fig. 8 c the second column is introduced by a square plate, in Fig. 8 d by a heptagonal plate. In Fig. 6 e the fifth column is introduced by a square plate. In Figs. 7 b and c the first plate introducing a column is hex-

* Bull. Geol. Soc. Amer., vol. 7, p. 145.

agonal. In Fig. 12 a the third column begins with a hexagagonal plate and in Fig. 4 a the first column introduced begins with a hexagonal plate.

Then, again, the initial plate of a column when pentagonal often has the apex pointing dorsally, and I am unable to understand how this feature can be "an important aid in diagnosing the relative position of the axes in even fragmentary specimens," as claimed by Jackson and Jaggar.* Having a piece of perhaps only a dozen plates, it is impossible to determine anything at all about it — such a specimen having no value in the determination of characteristics. The only thing which can fix the relative position of the axes positively is the presence of the apical disk or the masticatory apparatus, or, at least, of the space once occupied by those organs.

It is to be regretted that scientists are ever ready to create new species from mere fragments, or because a specimen shows an additional column, or because the individual plates are larger or smaller than usual. All these features are of only secondary importance and should never be considered of generic or even specific value. Any feature to be truly of importance in determining species must be constant and typical in all specimens belonging to that species. The greatest care should be exercised in basing new genera or even new species on a single specimen or a fragment. Palaeontologists very often, in their eagerness to describe their specimens, cause a great deal of confusion by creating new species and burden the literature with many synonyms, which it may take years and the labor of a number of scientists to eradicate. So Mr. Beede in describing his Oligoporus ? minutus says: †
"It will in all probability be found to belong to an entirely different genus. It is referred to *Oligoporus* for convenience, until better material can be secured." Since the author feels almost sure that the specimen does not belong to that genus, why burden the science with a meaningless name instead of waiting for better material and then describing and placing the fossil in its proper place? So Mr. Keyes adds to the list

* Bull. Geol. Soc. Amer., vol. 7, p. 149.

† Kansas University Quarterly, Series A, vol. 8, no. 3, p. 126.

of synonyms by describing *Eocidaris hallianus* as *Archaeocidaris hallianus* on the strength of some plates he found at Kansas City, Mo., but, concerning whose identity he is not very sure, as he adds: "If the identification of the Kansas City specimen is correct, it seems probable that this form should more properly come under Archaeocidaris than Eocidaris." * Why not leave species where placed until positive of their proper place?

If writers would keep in mind, that, in all probability, the laws of distribution in geological ages were about as they are at present, they would not describe fifty or more species of one genus from one and the same locality. If we look at the distribution of plants and animals to-day, we find only a very few species of one genus occurring at the same place. Why should we not assume the most logical thing, namely, that the same laws existed in the geological ages, and, when we find only slight differences in our specimens, ascribe them to abnormal development, at least, until we find that the feature first noticed, predominates in a large collection from the same locality or from the same geological horizon.

Another feature, that should never be lost sight of, is the probable condition under which the animal in question lived and thrived. Just as living plants and animals develop more rapidly under favorable conditions — such as plenty of light, air and food — so, undoubtedly, the rapidity of development in plants and animals during geological times was influenced to a high degree by the surrounding conditions. No doubt, a Melonite with an insufficient supply of food, light and air, secreted only small plates, while under more favorable conditions, the deposits would have been more rapid, and, consequently, the plates larger. The specimen figured on Pl. IV., Fig. 8, is the same species as the one on Pl. V., Fig. 9, although in the latter the plates are twice as large.

As we find a great variation in the size of the individual plates, we must necessarily find as great a variation in the number of plates composing a column and also in the number of rows. It is not an uncommon thing to find a great differ-

* Missouri Geological Survey, vol. 4, p. 129.

ence in the size of the individual plates, in the number of plates in a column and in the number of columns in two specimens of about the same size.

In the examination of the large material at my command, I have become fully convinced that the number of columns, the number of plates composing a column and the size of the individual plates are such variable features that they cannot be considered of primary specific importance. Of much greater value are the ornamentation of the plates, the general shape of the specimen and the number of columns in the ambulacrum. The ambulacral areas are much more important structurally, as they always show a definite number of columns, which forms a very good basis for generic separation. The sole object of the interambulacral areas, as of the interradials in Crinoideae, seems to be to fill out space. For this reason interambulacral plates should be considered of secondary importance.

Having discussed the interambulacral plate arrangement, I beg now to call the reader's attention for a few moments to the ornamentation of the plates, which is a very important feature in classification. All species belonging to the *Melonitidae* are covered evenly with small short spines, which in some cases show surface ornamentations. Spines are a very good feature for specific distinction. In *Melonites multiporus* the spines of the interambulacra and those of the ambulacra are about the same size, while in *Melonites crassus*, those of the interambulacra are only about half as long as those of the ambulacra. This feature gives the specimen quite a characteristic appearance. If the difference in the length of the spines were the result of erosion, as Jackson and Jaggar* claim, we should find the same thing in *Melonites multiporus*, where, however, the spines of both fields are always practically one size. After examining the type specimen of *Melonites crassus* from which Dr. Hambach's figure † was made, and after a very careful comparison with numerous specimens of *Melonites multiporus*, I am fully convinced that the professor

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* Bull. Amer. Geol. Soc., vol. 7, p. 138.

† Trans. St. Louis Acad. Sci., vol. 4, Pl. C, Fig. 1.

was amply justified in considering the size of the spines of specific importance.

In connection with the ornamentation, must be considered the imbrication of plates, which is also a very characteristic feature. In the *Melonitidae* the imbrication is very slight, while it is very marked in *Lepidocentrus*, *Lepidechinus* and their allies. The imbrication of plates or the lack of it is a very good feature for separation, as its presence or absence gives the specimen a peculiar appearance.

In concluding this general discussion, I wish to say a few words about the genital and ocular plates.

Among the Palaeozoic Echini the apical system of several genera is known, showing very different types. In *Echinocystis* the apical disk is unknown. The madreporic plate is separated from the apex and is interambulacral. The anus is excentric and interambulacral, but near the apex.

In *Perischodomus*, *Perischocidaris* and *Palaechinus sphericus*, the oculars are wanting, the five genitals forming a closed ring around the anus. In *Perischocidaris* there are sixteen pores to each genital plate. In *Perischodomus* the genitals are perforated by six or eight pores.

In *Bothriocidaris* there are five large ocular plates around the anus with small three-cornered pieces inserted between. The apical system consists of ten plates and a ring of ten smaller plates within these.

In *Palaechinus*, *Oligoporus*, and *Melonites* the oculars and genitals form a circle of ten pieces. In *Palaechinus elegans* there are two rings of ten pieces each. Each genital plate is pierced by three pores and each ocular by two pores. This feature, however, is subject to great variations. In some cases the oculars are without any trace of pores, and in others there is a single pore in two of them. The genitals vary even more than the oculars. In some three plates are pierced by four pores, and the other two by five; or three may have four pores and the other two, three pores each.

## Synopsis of the Orders, Families, Genera and Species of the Palaeozoic Palaëchinoidea.

The mistake of considering the variations in the different parts of the corona of specific importance has led to the creation of many new species throughout the subkingdom of the Radiates, which, in reality, are mere deviations of already existing species. It is a well established fact that no subkingdom is so subject to variations as that of the Radiates. Deviations from the pentamerous arrangement are the rule rather than the exception. In the light of this knowledge authors should be very chary about describing new species with variable features as a basis. Any classification to be of value must rest on features which are constant and typical. Among the *Palaeëchinoidea* the prevailing characters which may be taken as a basis for classification are the following: —

1. Number of columns in the ambulacra.
2. Position and number of the ambulacral pores.
3. Ornamentation of the plates.
4. Imbrication of the plates.
5. Apical system.
6. General shape of the body.
7. Geological position.

### *Classification.*

Class **ECHINOIDEA**.

Subclass **Palaeëchinoidea**.

Order A. CYSTOCIDAROIDA.

Fam. I. Palaeodiscidae.

Genus a. *Palaeodiscus.*

Fam. II. Echinocystidae.

Genus a. *Echinocystis.*

Order B. BOTHRIOCIDAROIDA.

Fam. I. Bothriocidaridae.

Genus a. *Bothriocidaris.*

Order C. PERISCHOËCHINOIDA.

Fam. I. Lepidocentridae.

Genus a. *Lepidocentrus.*
b. *Perischodomus.*
c. *Lepidechinus.*

Fam. II. Lepidesthidae.

Genus a. *Pholidocidaris.*
b. *Lepidesthes.*

Fam. III. Melonitidae.

Genus a. *Rhoechinus.*
b. *Palaechinus.*
c. *Oligoporus.*
d. *Melonites.*

Fam. IV. Archaeocidaridae.

Genus a. *Archaeocidaris.*
b. *Eocidaris.*
c. *Lepidocidaris.*

DOUBTFUL GENERA.

1. Discocystis.
2. Echinodiscus.
3. Eotiaris.
4. Koninckocidaris.
5. Leptechinus.
6. Myriastiches.
7. Permocidaris.
8. Proterocidaris.
9. Protocidaris.
10. Protoechinus.
11. Spatangopsis.
12. Xenocidaris.

**Palaeëchinoidea** Zittel 1879.*

Body composed of more than twenty columns of plates, except one order, *Bothriocidaroida*, which has less than twenty columns. Plates imbricating or not imbricating.

* Handbuch der Palaeontologie Bd. 1, p. 478.

Apical disk composed of five or ten plates, which may or may not be perforated. In all, except in *Echinocystis*, the anus is central and surrounded by the apical disk.

## A. CYSTOCIDAROIDA Zittel 1879.*

Test composed of thin, spine-bearing plates. Ambulacral area consists of two or four columns of plates, each plate pierced by a central pair of pores. Interambulacrum broad, composed of numerous columns of irregular, scale-like plates, each plate bearing a small primary tubercle, surrounded by a scrobicule. Anus aboral, in *Echinocystis* in the posterior interambulacrum. Peristome small with highly developed jaws. Mouth central. No apical plates.

### I. Palaeodiscidae Gregory 1897.†

Body depressed, discoid. Ambulacra composed of two columns of plates crowded together. On the oral surface they are imperforate, while near the aboral pole pores occur. Anus central.

#### a. Palaeodiscus Salter 1857.‡

Body discoid, test thin, flexible. Ambulacra broad with a series of single pores on each side on the aboral surface. On the oral surface, the ambulacral plates are simple, thin and bar-shaped. On the aboral surface there are two alternate series of simple, thin, bar-shaped plates. The interambulacral plates are angular, irregular and scale-like, covered with numerous short spines. Apical plates not known.

##### 1. Palaeodiscus ferox Salter.

1857. *Palaeodiscus ferox.* Salter, Ann. Mag. Nat. Hist., ser. 2, vol. 20, p. 332, pl. 9, fig. 6.

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* Handbuch der Palaeontologie Bd. 1, p. 480.

† Quart. Journ. Geol. Soc. London, vol. 53, pt. 1, p. 133.

‡ Ann. Mag. Nat. Hist., ser. 2, vol. 20, p. 332.

1881. *Palaeodiscus ferox.* Neumayr, Sitzb. K. Akad. Wiss. Wien, Bd. 84, Abth. 1, p. 155, taf. 1, fig. 8.
1897. *Palaeodiscus ferox.* Gregory, Quart. Journ. Geol. Soc. London, vol. 53, pt. 1, p. 129, pl. 7, fig. 5.
1899. *Palaeodiscus ferox.* Sollas, Quart. Journ. Geol. Soc. London, vol. 55, pt. 4, p. 701, figs. 6–11.

Body composed of large plates furnished with spines. Seven or eight columns in each interambulacrum. Ambulacra composed of long, thin plates in two rows. Powerful teeth known.

Geological formation and locality: Lower Ludlow, Leintwardine Flags.

## II. Echinocystidae Gregory 1897.*

Body spherical. Ambulacral plates perforated by a pore pair each. Pore pairs biserial. Most of the plates low primaries, but demi-plates occur. Mouth central, anus excentric, opening in posterior interambulacrum and protected by a group of large plates. Apical plates absent. Jaws large and powerful.

### a. Echinocystis Thomson 1861.†

Syn. Cystocidaris Zittel 1879.‡

Body spheroidal, test thin and flexible. Ambulacra consist of four columns of small, simple, demi-plates with biserial pore pairs. The interambulacra consist of ten columns each usually of numerous, irregular, angular plates, most of which bear small granules, supporting short, sharp, movable spines.

#### 1. Echinocystis pomum Thomson.

1861. *Echinocystis pomum.* Thomson, Edin. New. Phil. Journ., n. s. vol. 13, p. 106, pl. 3, 4.
1861. *Echinocystis uva.* Thomson, Edin. New Phil. Journ., n. s. vol. 13, p. 106, pl. 4.

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* Quart. Journ. Geol. Soc. London, vol. 53, pt. 1, p. 133.
† Edin. New Phil. Journ., n. s. vol. 13, p. 106.
‡ Handbuch der Palaeontologie Bd. 1, p. 480.

1897. *Echinocystis pomum.* Gregory, Quart. Journ. Geol. Soc. London, vol. 53, pt. 1, p. 124, pl. 7, fig. 4.

1899. *Echinocystis pomum.* Sollas, Quart. Journ. Geol. Soc. London, vol. 55, pt. 4, p. 707, figs. 12–14.

A row of minute tubercles border the ambulacra on the outer margin, and a double row of even smaller tubercles runs along each side of the middle line. Porepairs lie in an oval depression.

Geological formation and locality: Leintwardine Flags, Lower Ludlow, near Leintwardine, Shropshire.

## B. BOTHRIOCIDAROIDA Zittel 1879.*

Test regular, spherical. Two columns of plates in the ambulacral area and a single column in each interambulacral area. Plates do not imbricate. Periproct in the apical system.

### I. Bothriocidaridae Schmidt 1874.†

Body round, regular. Anal within the apical disk. Apical disk composed of a ring of five large and five small plates. Two pores in each ambulacral plate. Mouth surrounded by ten perforated plates in front of which are three-cornered small plates.

#### a. Bothriocidaris Eichwald 1860.‡

Body round, anus within the apical system, mouth opposite.

Plates not flexible. Apical system composed of five large and five small plates, within which is the anus closed by six or eight linear or oval plates, each of which has a spine on the end. Two pores in each of the larger plates, while the smaller plates are imperforate.

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* Handbuch der Palaeontologie Bd. 1, p. 480.

† Mém. Acad. Imp. St. Petersburg, (7) vol. 21, no. 11, p. 36.

‡ Lethaea Rossica, p. 654.

### 1. Bothriocidaris globulus Eichwald.

1860. *Bothriocidaris globulus.* Eichwald, Lethaea Ross. anc. Per., p. 655, taf. 32, fig. 22 a, b.
1874. *Bothriocidaris globulus.* Schmidt, Mém. Acad. Imp. Sci. St. Petersbourg, série 7, tome 21, no. 11, p. 37.
1894. *Bothriocidaris globulus.* Jaekel, Sitz. Gesell. Naturfor. Freunde, Berlin, p. 245.

Each ambulacral plate bears four perforated spines, and each interambulacral plate from one to three perforated spines. The genital plates are separated by the ocular plates.

Geological formation and locality: Silurian, Dago, Russia.

### 2. Bothriocidaris phaleni Schmidt.

1874. *Bothriocidaris Phaleni.* Schmidt, Mém. Acad. Imp. Sci. St. Petersbourg, série 7, tome 21, no. 11, p. 34, tab. 4, figs. 1 a–g.
1892. *Bothriocidaris Phaleni.* Agassiz, Mem. Mus. Comp. Zool., vol. 17, no. 2, p. 72, pl. 29, fig. 1.
1894. *Bothriocidaris Phaleni.* Jaekel, Sitzb. Gesell. Naturfor. Freunde, Berlin, p. 246.

Each ambulacral plate bears two perforated spines. No spines on the interambulacral plates. The five genital plates are in contact with each other.

Geological formation and locality: Lower Silurian, Nömmis, Russia.

## C. PERISCHOECHINOIDA M'Coy 1849.*

Syn. Tessellati Desor 1858.†

Body round or elliptical. More than two columns of plates in the interambulacrum (sometimes also in the ambulacrum).

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* Ann. Mag. Nat. Hist. (2), vol. 3, p. 251.

† Synopsis des Echinides 1858, p. 152.

Plates imbricate more or less, the interambulacral aborally, the ambulacral adorally. Mouth and anus opposite, the anus within the apical disk. Apical system consists of five genital plates, each pierced by from two to five pores, and five ocular plates, which are sometimes pierced by two pores.

### I. Lepidocentridae Lovén 1874.*

Interambulacral plates imbricate aborally and outward. Adambulacral plates larger and bearing more and larger tubercles. More than two columns of plates in the interambulacrum. Ambulacral pore pairs usually in a single series.

#### a. Lepidocentrus Müller 1856.†

Usually five columns in the interambulacrum. Edges of the middle row beveled, side columns rather four than six sided. Adambulacral plates large with rounded edges. Ambulacral plates small, two columns of low six-sided inflexible plates. Two pores to each plates in vertical rows. Spines very small and pointed. Tubercles small and far apart. Masticatory apparatus present.

##### 1. Lepidocentrus eifelianus Müller.

1856. *Lepidocentrus eifelianus.* Müller, Abhandl. K. Akad. Wiss. Berlin, p. 258, pl. 3, figs. 1–8.
1858. *Lepidocentrus eifelianus.* Müller, Monatsber. K. Preuss. Akad. Wiss., p. 197.
1866. *Lepidocentrus Eifelianus.* Schultze, Denkschrift K. Akad. Wiss., Wien, Math.-Naturwiss. Cl., No. 26, p. 123, tab. 13, fig. 2.
1871. *Lepidocentrus eifelianus.* Kayser, Zeitsch. deut. geol. Gesell. Bd. 33, p. 340, 371.
1874. *Lepidocentrus eifelianus.* Lovén, Kongl. Svens. Vetens. Akad. Handl., Bd. 11, no. 7, p. 40.

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* Kongl. Svens. Vetens. Akad. Handl. Bd. 11, no. 7, p. 39.

† Abhandl. K. Akad. Wiss. Berlin, 1856, p. 258.

1875. *Lepidocentrus Eifelianus.* Quenstedt, Petrefact. Deutsch., Bd. 3, Abth. 1, p. 374, tab. 75, figs. 14–17.

1896. *Lepidocentrus eifelianus.* Jackson, Bull. Geol. Soc. Amer., vol. 7, p. 225.

Plates thin and quite round. Interambulacral plates scale-like with rounded sides. Spines small, acicular, swollen at the base. Most plates have one large tubercle, convex, perforated, with a smooth ring.

Geological formation and locality: Devonian, Rommersheim.

### 2. Lepidocentrus mülleri Schultze.

1866. *Lepidocentrus Mülleri.* Schultze, Denkschrift K. Akad. Wiss. Wien, No. 26, p. 124, tab. 13, fig. 1.

1874. *Lepidocentrus Mülleri.* Lovén, Kongl. Svens. Vetens. Akad. Handl., Bd. 11, No. 7, p. 40.

1896. *Lepidocentrus mulleri.* Jackson, Bull. Geol. Soc. Amer., vol. 7, p. 223, fig. 2.

Ambulacral areas composed of two columns of low narrow regular plates, each perforated by two pores. Interambulacral plates imbricating strongly adorally and laterally. Interambulacral plates nearly rhombic with one large primary boss. Secondary spine bosses scattered over the surface. Spines small, acicular and swollen at the base.

Geological formation and locality: Devonian, Rommersheim near Prom, Eifel; Gerolstein, Eifel.

### 3. Lepidocentrus rhenanus Beyrich.

1856. *Palaechinus rhenanus.* Beyrich, Zeitschrift Deut. Geol. Gesell., Bd. 9, p. 4.

1856. *Lepidocentrus rhenanus.* Müller, Abhandl. K. Akad. Wiss. Berlin, p. 264, pl. 4, figs. 4–6.

1874. *Lepidocentrus rhenanus.* Lovén, Kongl. Svens. Vetens. Akad. Handl., Bd. 11, no. 7, p. 40.

1875. *Palaeocidaris Rhenanus.* Quenstedt, Petrefact. Deutschl., p. 377, tab. 75, fig. 30–37.

1896. *Lepidocentrus rhenanus.* Jackson, Bull. Geol. Soc. Amer., vol. 7, pr. 224.

Interambulacral plates nearly hexagonal, with the corners rounded. Five columns in each intrambulacrum, and two in each ambulacrum.

Geological formation and locality: Devonian, Wipperfürth.

### b. Perischodomus M'Coy 1849.*

Syn. Perischocidaris Neumayr 1881.†

Homotoechus Sollas 1892.‡

Tretechinus Tornquist 1897.§

Body round or nearly so. Interambulacra broad, consisting of five columns of irregular plates. Adambulacral plates larger and bearing one perforated tubercle near the ambulacral edge. Other plates covered with small granulated tubercles close together. Ambulacra consist of two columns (sometimes more) of small, low plates pierced by a pair of pores each. Spines smooth and cylindrical. Mouth and anus small, both central. Genital plates pierced by six or eight pores. Plates imbricate.

#### 1. Perischodomus biserialis M'Coy.

1849. *Perischodomus biserialis.* M'Coy, Ann. Mag. Nat. Hist., ser. 2, vol. 3, p. 253.

1854. *Perischodomus biserialis.* M'Coy, Cont. Brit. Pal., p. 115.

1858. *Perischodomus biserialis.* Desor, Syn., p. 157.

1862. *Perischodomus biserialis.* Dujardin et Hupé, Echinodermes, p. 466.

1874. *Perischodomus biserialis.* Lovén, Kongl. Svens. Vetens. Akad. Handl., bd. 11, no. 7, p. 40.

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* Ann. Mag. Nat. Hist., ser. 2, vol. 3, p. 253.

† Sitzb. K. Akad. Wiss. Wien, Math. Naturw. Cl., bd. 84, abth. 1, p. 174.

‡ Scient. Proc. Roy. Dub. Soc., n. s. vol. 7, pt. 3, p. 153.

§ Abhdl. Geol. Karte Elsass-Lothringen, Bd. 5, heft 6, p. 784.

1875. *Perischodomus biserialis.* Quenstedt, Petrefact. Deutschl., bd. 3, abth. 1, p. 374, tab. 75, fig. 13.

1876. *Perischodomus biserialis.* Keeping, Quart. Journ. Geol. Soc., vol 32, pt. 1, p. 36, pl. 3, figs. 1–5.

1896. *Perischodomus biserialis.* Jackson, Bull. Geol. Soc. Amer., vol. 7, p. 226.

Interambulacra consist of five columns of irregular, very finely granulated plates. Adambulacral plates bear small, mammillated, perforated, primary tubercles. Two columns of small plates in each ambulacrum.

Geological formation and locality: Lower Carboniferous, Hook Head, Wexford, England.

### 2. Perischodomus hartei Baily.

1864. ——— ——— Harte, Dub. Quart. Journ. Sci., vol. 5, p. 265, pl. 9.

1864. ——— ——— Harte, Journ. Roy. Geol. Soc. Ireland, ser. 2, vol. 1, pt. 1, p. 67, pl. 5.

1874. *Archaeocidaris Harteiana.* Baily, Journ. Geol. Soc. Ireland, n. s. vol. 4, pt. 1, p. 42, pl. 4, figs. a–c.

1875. ——— ——— Quenstedt, Petrefact. Deutschl., vol. 1, p. 379.

1875. *Archaeocidaris Harteiana.* Baily, Char. Brit. Foss., vol. 1, p. lxviii.

1881. *Perischocidaris Hartei.* Neumayr, Sitzb. K. Akad. Wiss. Wien, Math.-Naturw. Cl., Bd. 84, Abth. 1, p. 174, taf. 1, fig. 7.

1892. *Homotoechus Hartii.* Sollas, Scient. Proc. Roy. Dub. Soc., n. s. vol. 7, pt. 3, p. 153.

Genital plates have each a large perforated tubercle, surrounded by a depressed ring, which is further surrounded by sixteen pores. Adambulacral plates bear tubercles on the first, second, fourth and seventh, while the third, fifth and sixth plates are plain. Ambulacra large, pores in two depressions, with three pair of pores in each ambulacral depression. One small tubercle on each ambulacral plate.

Geological formation and locality: Yellow sandstone, Donegal, Ireland.

3. Perischodomus illinoiensis Worthen and Miller.

1883. *Perischodomus Illinoiensis.* Worthen and Miller, Geol. Surv. Ill., vol. 7, p. 333, pl. 31, fig. 8.
1889. *Perischodomus illinoisensis.* Miller, N. Amer. Geol. Pal., p. 269.
1895. *Perischodomus ?? illinoisensis.* Keyes, Proc. Iowa Acad. Sci., vol. 2, p. 191.
1897. *Tretechinus illinoiensis.* Tornquist, Abhdl. Geol. Karte Elsass-Lothringen, Bd. 5, Hft. 6, p. 784.

Interambulacra consist of five ? rows of irregular plates, imbricating upward and outward. Ambulacra composed of five columns of narrow depressed plates overlapped by the interambulacral plates. Ambulacral plates pierced by a single pair of pores each, and imbricating slightly from above downward. Two kinds of spines present. The central supporting tubercle moderately large, smooth and perforated. Secondary spine bosses small, conical elevations with a minute perforation in each.

Geological formation and locality: Chester Limestone, Bay City, Pope Co., Ill.

INSUFFICIENTLY DETERMINED SPECIES.

1. Perischodomus magnus Tornquist.

1893. *Perischodomus magnus.* Tornquist, Mitth. Geol. Landesanst., Elsass-Lothr., Bd. 4, Heft. 2, p. 103.

Geological formation and locality: Devonian, Ober-Elsass, Germany.

c. Lepidechinus Hall 1861.*

General form subspheroidal. Interambulacra consist of from nine to eleven columns of plates imbricating aborally and sidewise. Ambulacra consist of two columns of plates imbricating in the opposite direction from those of the inter-

* Desc. New Species Crinoids, p. 18.

ambulacra. Plates narrow and pierced near the opposite extremity by two pores. Surface granulose. On the aboral side the adambulacral plates bear the smallest tubercles, the tubercles growing larger on the columns toward the center. On the oral side the ambulacra alone bear tubercles.

### 1. Lepidechinus imbricatus Hall.

1861. *Lepidechinus imbricatus.* Hall, Desc. New Spec. Crin., p. 18.
1874. *Lepidechinus imbricatus.* Lovén, Kongl. Svens. Vetens. Akad. Handl., Bd. 11, No. 7, p. 44.
1889. *Lepidechinus imbricatus.* Miller, N. Amer. Geol. Pal., p. 258.
1895. *Lepidechinus imbricatus.* Keyes, Proc. Iowa Acad. Sci., vol. 2, p. 192.

Eight columns in each interambulacrum, plates imbricating. Ambulacra narrow, composed of short wide plates, deeply interlocking at the joined edges and imbricating in the opposite direction from those of the interambulacrum. The upper adjacent angles of the interlocking edges are neatly rounded, giving a curved outline to nearly half their width on the exposed edge. Two small pores pierce each plate near its outer extremity. Surface granulose.

Geological formation and locality: Burlington Limestone, Burlington, Iowa.

### 2. Lepidechinus rarispinus Hall.

1867. *Lepidechinus rarispinus.* Hall, 20th Rep. N. Y. State Cab. Nat. Hist., p. 295, pl. 9, fig. 10.
1870. *Lepidechinus rarispinus.* Hall, 20th Rep. N. Y. State Cab. Nat. Hist. (rev. ed.), p. 340, pl. 9, fig. 10.
1874. *Lepidechinus rarispinus.* Lovén, Kongl. Svens. Vetens. Akad. Handl., Bd. 11, No. 7, p. 44.
1889. *Lepidechinus rarispinus.* Miller, N. Amer. Geol. Pal., p. 258.
1895. *Lepidechinus rarispinus.* Keyes, Proc. Iowa Acad. Sci., vol. 2, p. 192.

1896. *Lepidechinus rarispinus.* Jackson, Bull. Geol. Soc. Amer., vol. 7, p. 226, pl. 7, figs. 1, 2.

Test spherical or depressed spheroidal. Interambulacrum composed of from seven to nine columns of plates, which imbricate from below upward and from the middle outward. Large central tubercle on each plate. In this species there is a central range of vertically imbricating plates which cover the lateral margins of the adjoining columns, making the lateral imbrication pass beneath, instead of showing an alternation along the middle line. Ambulacra narrow, composed of two rows of small low plates, each pierced by two pores near the distal extremity.

Geological formation and locality: Chemung, Meadville, Pa.; Waverly, Licking Co., Ohio.

## II. Lepidesthidae Jackson 1896.*

Spherical or subspheroidal test. Six or more columns in each ambulacrum and generally ten in each interambulacrum. Plates imbricate. Pores in the center of each ambulacral plate.

### a. Pholidocidaris Meek and Worthen 1869.†

Ambulacra quite broad composed of six columns of small irregular oval or rhombic plates, imbricating aborally and provided each with a tubercle and two pores in a deep furrow. Interambulacrum consists of five or more columns of thin, rounded, arched, granulated, irregular plates, imbricating aborally and outward. Adambulacral plates three or four times as large as the others. On the lower (?) side the interambulacral plates have a central, perforated primary tubercle. Spines large and striated.

#### 1. Pholidocidaris irregularis Meek and Worthen.

1869. *Lepidocentrus irregularis.* Meek and Worthen, Proc. Acad. Nat. Sci. Phil., p. 78.

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* Bull. Geol. Soc. Amer., vol. 7, p. 241.

† Proc. Acad. Nat. Sci. Phil., 1869, p. 78.

1873. *Pholidocidaris irregularis.* Meek and Worthen, Geol. Surv. Ill., vol. 5, p. 512, pl. 15, fig. 9.
1874. *Pholidocidaris irregularis.* Meek, Amer. Journ. Sci., ser. 3, vol. 7, p. 375.
1874. *Pholidocidaris irregularis.* Lovén, Kongl. Svens. Vetens. Akad. Handl., Bd. 11, no. 7. p. 40.
1889. *Pholidocidaris irregularis.* Miller, N. Amer. Geol. Pal., p. 269.
1895. *Pholidocidaris irregularis.* Keyes, Proc. Iowa Acad. Sci., vol. 2, p. 180.
1896. *Pholidocidaris meeki.* Jackson, Bull. Geol. Soc. Amer., vol. 7, p. 210, pl. 9, fig. 54.

Interambulacral plates thin and sharp at the edges. Primary tubercle present on lower (?) part only and on the marginal plates, in the upper (?) part. Ambulacral plates very irregular, six or more columns. Pores in pits in the center of each plate, surrounded by a circular depression. Primary spines taper gradually, are rounded, nearly straight, and marked with minute, crowded longitudinal striae.

Geological formation and locality: Keokuk and Hamilton Groups, near Nauvoo and Warsaw, Ill.

## INSUFFICIENTLY DETERMINED SPECIES.

### 1. Pholidocidaris gaudryi Julien.

1874. *Lepidocentrus Münsterianus.* Julien, Compt. Rend. Acad. Sci. Paris, T. 78, p. 76.
1890. *Melonites Gaudryi.* Julien, Compt. Rend. Acad. Sci. Paris, T. 110, p. 737.
1896. *Pholidocidaris Gaudryi.* Julien, Terr. Carb. Marin de la France Centrale, p. 131, pl. 6, figs. 1, 2, 6, 7.

Geological formation and locality: Carboniferous, l'Ardoisière.

### 2. Pholidocidaris tenuis Tornquist.

1897. *Pholidocidaris tenuis.* Tornquist, Abhdl. Geol. Karte Elsass-Lothr., Bd. 5, Hft. 6, p. 767, taf. 21, figs. 8, 9; taf. 22, fig. 8.

Geological formation and locality: Lower Carboniferous, Hunsrückenwald, Elsass, Germany.

### b. Lepidesthes Meek and Worthen 1868.*

Syn. Hybochinus Worthen and Miller 1883.†

Test subspheroidal. Interambulacra composed of 6–7 columns of plates, imbricating aborally. Ambulacra very wide, composed of ten columns of small plates, imbricating adorally. Two pores to each ambulacral plate, placed centrally. Surface covered with small granules.

#### 1. Lepidesthes colletti White.

1878. *Lepidesthes Colletti.* White. Proc. Acad. Nat. Sci. Phil., p. 33.
1880. *Lepidesthes colletti.* White, Cont. to Inv. Pal. No. 8, p. 163, pl. 40, figs. 2 a–b.
1882. *Lepidesthes colletti.* White, 11th Rep. Geol. Surv. Ind., p. 362, pl. 41, figs. 2, 3.
1889. *Lepidesthes colletti.* Miller, N. Amer. Geol. Pal., p. 258.
1895. *Lepidesthes colletti.* Keyes, Proc. Iowa Acad. Sci., vol. 2, p. 184.
1896. *Lepidesthes colletti.* Jackson, Bull. Geol. Soc. Amer., vol. 7, p. 210.

General form ovate. Interambulacra very narrow, composed of four or five columns of small plates. Ambulacra broad, composed of from eighteen to twenty rows of small imbricating plates. Two round pores near the upper angle of each ambulacral plate. Surface covered with small granules.

Geological formation and locality: Keokuk Group, Salem, Washington Co., Ind.; Crawfordsville, Ind.

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* Geol. Surv. Ill., vol. 3, p. 522.

† Geol. Surv. Ill., vol. 7, p. 331.

### 2. Lepidesthes coreyi Meek and Worthen.

1868. *Lepidesthes Coreyi.* Meek and Worthen, Geol. Surv. Ill., vol. 3, p. 525, fig. A.
1873. *Lepidesthes Coreyi.* Meek and Worthen, Geol. Surv. Ill., vol. 5, pl. 16, figs. 2 a–b.
1874. *Lepidesthes Coreyi.* Lovén, Kongl. Svens. Vetens. Akad. Handl., Bd. 11, no. 7, p. 42.
1889. *Lepidesthes coreyi.* Miller, N. Amer. Geol. Pal., p. 258, fig. 350.
1895. *Lepidesthes coreyi.* Keyes, Proc. Iowa Acad. Sci., vol. 2, p. 184.
1896. *Lepidesthes coreyi.* Jackson, Bull. Geol. Soc. Amer., vol. 7, p. 209.

General form subspheroidal. Interambulacra narrow, lanceolate, slightly convex, composed of six or seven columns. Ambulacra flat, broadly lanceolate and one and a half or twice as wide as the interambulacra, composed of ten or eleven columns of plates, all imbricating. Two small round pores in the center. Surface covered with fine granules, from eighteen to twenty-five to the larger interambulacral pieces.

Geological formation and locality: Keokuk Group, Crawfordsville, Indiana.

### 3. Lepidesthes formosus Miller.

1879. *Lepidesthes formosus.* Miller, Journ. Cinn. Soc. Nat. Hist., vol. 2, p. 41, pl. 8, fig. 4.
1889. *Lepidesthes formosus.* Miller, N. Amer. Geol. Pal., p. 258.
1895. *Lepidesthes formosus.* Keyes, Proc. Iowa Acad. Sci., vol. 2, p. 184.
1896. *Lepidesthes formosus.* Jackson, Bull. Geol. Soc. Amer., vol. 7, p. 210.

General form subspheroidal. Interambulacra composed of five columns of plates, imbricating upward and outward. Ambulacra occupied by eight or nine columns each of many rhombic or irregularly hexagonal plates, imbricating downward. Two pores in the center of each ambulacral piece.

Geological formation and locality: Kaskaskia Group, Pulaski Co., Ky. Keokuk Shales, Crawfordsville, Ind.

### 4. Lepidesthes spectabilis Worthen and Miller.

1883. *Hybochinus spectabilis.* Worthen and Miller, Geol. Surv. Ill., vol. 7, p. 332, pl. 31, figs. 5 a–d, 6, 7.
1889. *Hybochinus spectabilis.* Miller, N. Amer. Geol. Pal., p. 255.
1895. *Lepidesthes spectabilis.* Keyes, Proc. Iowa Acad. Sci., vol. 2, p. 184.

Test subspheroidal. Five columns of plates in each interambulacrum, plates imbricating downward and outward. Ambulacrum composed of ten columns of plates imbricating from below upward. Two pores in the center of each ambulacral plate. Surface covered with small granules.

Geological formation and locality: Chester Limestone, Prairie du Long Creek, Monroe Co., Ill.; Pope Co., Ill.

### 5. Lepidesthes wortheni Jackson

1896. *Lepidesthes wortheni.* Jackson, Bull. Geol. Soc. Amer., vol. 7, p. 207, pl. 9, fig. 53.

Interambulacral areas consist of three or four columns of quite large hexagonal pieces. Ambulacra have seven or eight columns of many small imbricating pieces with two pores in the center of each piece.

Geological formation and locality: Keokuk Group, Crawfordsville, Ind. (?).

## INSUFFICIENTLY DETERMINED SPECIES.

### 1. Lepidesthes devonicans Whidborne.

1898. *Lepidesthes devonicans.* Whidborne, Pal. Soc. Mon., vol. 52, p. 200, pls. 24, 25.

Geological formation and locality: Pilton Beds, North Devon and Croyde.

2. Lepidesthes laevis Trautschold.

1879. *Lepidesthes laevis.* Trautschold, Mém. Soc. Imp. Nat. Moscow, t. 14, p. 8.

Geological formation and locality: Subcarboniferous, Mjatschkowa, Russia.

## III. Melonitidae Zittel, 1879.*

Syn. Palaechinidae M'Coy 1849.†

Meloncchinidae Lambert 1900.‡

Test spherical with never less than five columns of plates in each interambulacrum. Surface of the whole body covvered evenly with fine short spines.

### a. Rhoechinus Keeping 1876.§

From five to nine columns of plates in each interambulacrum and two columns in each ambulacrum. Two pores in each ambulacral plate.

1. Rhoechinus burlingtonensis Meek and Worthen.

1860. *Palaechinus Burlingtonensis.* Meek and Worthen, Proc. Acad. Nat. Sci. Phil., p. 396.

1866. *Palaechinus burlingtonensis.* Meek and Worthen Geol. Surv. Ill., vol. 2, p. 230, pl. 16, figs. 3 a–c.

1874. *Palaechinus burlingtonensis.* Lovén, Kongl. Svens. Vetens. Akad. Handl., Bd. 11, no. 7, p. 41.

1889. *Palaechinus burlingtonensis.* Miller, N. Amer. Geol. Pal., p. 266, fig. 382.

1895. *Palaechinus burlingtonensis.* Keyes, Proc. Iowa Acad. Sci., vol. 2, p. 180.

* Handbuch der Palaeontologie, bd. 1, p. 484.

† Ann. Mag. Nat. Hist., ser. 2, vol. 3, p. 251.

‡ Bull. Soc. Sci. Hist. Nat. L'Yonne, vol. 53, p. 53.

§ Quart. Journ. Geol. Soc. Lond., vol. 32, p. 37.

1896. *Rhoechinus burlingtonensis.* Jackson, Bull. Geol. Soc. Amer., vol. 7, p. 203.

Test spherical with four (?) columns of plates in each interambulacrum. Ambulacra narrow, composed of a double row of alternating large and small pieces, twice or three times as wide as long. Pores in a double zigzag row. Surface ornamentation small granules, from thirty to forty to each interambulacral plate.

Geological formation and locality: Burlington Limestone, Burlington, Iowa.

### 2. Rhoechinus elegans M'Coy.

1844. *Palaechinus elegans.* M'Coy, Foss. of Ireland, p. 172, pl. 24, fig. 2.
1850. *Palaechinus elegans.* D'Orbigny, Prodrome, vol. 1, p. 154.
1852. *Palaechinus elegans.* Roemer, in Bronn's Leth. Geog., Bd. 1, Th. 2, p. 287, tab. $4^1$, fig. 1 a–d.
1858. *Palaechinus elegans.* Desor, Syn., p. 158.
1862. *Palaechinus elegans.* Dujardin et Hupé Echinodermes, p. 463.
1865. *Palaechinus elegans.* Baily, Dub. Quart. Journ. Sci., vol. 5, p. 261, pl. 7.
1865. *Palaechinus elegans.* Baily, Geol. Mag., vol. 2, p. 44.
1865. *Palaechinus elegans.* Baily, Journ. Roy. Geol. Soc. Ireland, p. 63, pl. 4.
1874. *Palaechinus elegans.* Lovén, Kongl. Svens. Vetens. Akad. Handl., Bd. 11, No. 7, p. 41.
1874. *Palaechinus elegans.* Etheridge, Jr., Quart. Journ. Geol. Soc. Lond., vol. 30, pl. 24.
1875, *Palaechinus elegans.* Baily, Char. Brit. Foss., vol. 1, p. lxviii., pl. 36, figs. 11 a–d.
1875. *Palaechinus elegans.* Quenstedt, Petrefact. Deutschl., p. 380, tab. 75, fig. 43.
1889. *Rhoechinus elegans.* Duncan, Ann. Mag. Nat. Hist., ser. 6, vol. 3, p. 204.
1892. *Palaechinus elegans.* Agassiz A., Mem. Mus. Comp. Zool., vol. 17, no. 2, p. 73, pl. 29, fig. 2.

1894. *Palaechinus elegans.* Tornquist, Mitth. Geol. Landesanst. Elsass. Bd. 4, p. 100.

1896. *Rhoechinus elegans.* Jackson, Bull. Geol. Soc. Amer., vol. 7, p. 205, pl. 7, fig. 40.

1897. *Rhoechinus elegans.* Tornquist, Abhdl. Geol. Specialkarte Elsass. Loth., Bd. 5, Hft. 6, p. 757, taf. 20, figs. 10, 11, 12, taf. 21, fig. 6.

General shape ovate. Interambulacra composed of five columns each of mammillated plates, covered with very minute tubercles. Ambulacra large and convex. The lateral interambulacral plates equal five ambulacral plates in width.

Geological formation and locality: Carboniferous Limestone, Hook Head, Fethard, Wexford, England.

### 3. Rhoechinus gracilis Meek and Worthen.

1869. *Palaechinus gracilis.* Meek and Worthen, Proc. Acad. Nat. Sci. Phil., p. 82.

1873. *Palaechinus gracilis.* Meek and Worthen, Geol. Surv. Ill., vol. 5, p. 473, pl. 10, fig. 2.

1874. *Palaechinus gracilis.* Lovén, Kongl. Svens. Vetens. Akad. Handl., Bd. 11, no. 7, p. 41.

1889. *Palaechinus gracilis.* Miller, N. Amer. Geol. Pal., p. 266.

1895. *Palaechinus gracilis.* Keyes, Proc. Iowa Acad. Sci., vol. 2, p. 180.

1896. *Rhoechinus gracilis.* Jackson, Bull. Geol. Soc. Amer., vol. 7, p. 201, pl. 7, figs. 36, 37.

Body small. Seven columns in each interambulacrum. Plates ornamented with fine granules. Ambulacra wide in proportion, slightly convex, composed of very short pieces. Two pores at the outer end of each piece, arranged in two zigzag rows along the lateral margins of each ambulacral area. Plates ornamented with fine granules.

Geological formation and locality: Burlington Limestone, Burlington, Iowa. Waverly Group, Bever Creek, Menifee Co., Ky.

### 4. Rhoechinus irregularis Keeping.

1876. *Rhoechinus irregularis.* Keeping, Quart. Journ. Geol. Soc. Lond., vol. 32, pt. 1, p. 37, pl. 3, figs. 6–8.

Small and depressed at poles. Interambulacra composed of plates which are covered with minute sharp granules. Ambulacral areas sunk and narrow. The plates are transversely elongate with the pores in the center. One interambulacral plate is equal to four or five ambulacral plates. Both interambulacral and ambulacral plates imbricate.

Geological formation and locality: Carboniferous, Hook Head, Wexford Co., England.

### 5. Rhoechinus quadriserialis Wright.

1865. *Palaechinus quadriserialis.* Wright, Dub. Quart. Journ. Sci., vol. 5, p. 260, pl. 8, fig. 1.

1874. *Palaechinus quadriserialis.* Lovén, Kongl. Svens. Vetens. Akad. Handl., Bd. 11, No. 7, p. 41.

1889. *Palaechinus quadriserialis.* Duncan, Ann. Mag. Nat. Hist., ser. 6, vol. 3, p. 204.

General form elliptical. Interambulacral areas composed of four columns. One adambulacral plate equals in width six or seven ambulacral plates. Two rows of pores on each side of the ambulacra.

Geological formation and locality: Carboniferous, Ireland.

## Undetermined species.

### 1. Rhoechinus sp. Duncan.

1889. *Rhoechinus sp.* Duncan Ann. Mag. Nat. Hist., ser. 6, vol. 3, p. 204.

### 2. Rhoechinus (?) Tornquist.

1897. *Rhoechinus* (?). Tornquist, Abhdl. Geol. Special Karte Elsass-Lothr., Bd. 5, heft. 6, p. 763, taf. 20, fig. 8.

Geological formation and locality: Lower Carboniferous, Hunsrückenwald, Ober-Elsass, Germany.

### b. Palaechinus (Scouler) M'Coy 1844.*

Syn. Typhlechinus Neumayr 1889.†

From five to nine columns of plates in each interambulacrum and two columns in each ambulacrum. Four pores in each ambulacral plate.

#### 1. Palaechinus ellipticus Scouler.

1844. *Palaechinus ellipticus.* Scouler, M'Coy Foss. of Ireland, p. 172, pl. 24, fig. 3.
1847. *Echinocrinus ellipticus.* D'Orbigny, Cour de Pal., vol. 2, p. 126, fig. 278.
1850. *Palaechinus ellipticus.* D'Orbigny, Prodome, vol. 1, p. 154.
1854. *Palaeocidaris ellipticus.* Vogt, Lehrbuch d. Geol. u. Petref., Aufl. 2, Bd. 1, p. 332, figs. 212–214; Bd. 2, p. 482, fig. 928.
1858. *Palaechinus ellipticus.* Desor, Syn., p. 158.
1862. *Palaechinus ellipticus.* Dujardin et Hupé, Echinodermes, p. 464.
1865. *Palaechinus ellipticus.* Baily, Dub. Quart. Journ. Sci., vol. 5, p. 263, pl. 8, fig. 2.
1865. *Palaechinus ellipticus.* Baily, Geol. Mag., vol. 2, p. 217.
1874. *Palaechinus ellipticus.* Lovén, Kongl. Svens. Vetens. Akad. Handl., Bd. 11, No. 7, p. 41.
1875. *Palaechinus ellipticus.* Quenstedt, Petrefact. Deutschl., p. 380, tab. 75, fig. 42.
1889. *Palaechinus ellipticus.* Duncan, Ann. Mag. Nat. Hist., ser. 6, vol. 3, p. 200, fig. 8.
1893. *Palaechinus ellipticus* (?). Tornquist, Mitth. Geol. Landesanst. Elsass, Bd. 4, Hft. 2, p. 103.

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* Foss of Ireland, p. 171.

† Die Stämme des Thierreiches, Wirbellose Thiere, Bd. 1, p. 362.

General form elliptical. Interambulacra composed of five columns of plates, regularly marked with numerous tubercles. Ambulacra prominent, convex, with two rows of pores on each side. One lateral interambulacral plate is as wide as seven ambulacral plates.

Geological formation and locality: Carboniferous Limestone, Bettyville, Limerick Co., Ireland.

### 2. Palaechinus gigas M'Coy.

1844. *Palaechinus gigas.* M'Coy, Foss. of Ireland, p. 172, pl. 24, fig. 4.
1850. *Palaechinus gigas.* D'Orbigny, Prodrome, vol. 1, p. 154.
1858. *Palaechinus gigas.* Desor, Syn., p. 158.
1862. *Palaechinus gigas.* Dujardin et Hupé, Echinodermes, p. 463.
1874. *Palaechinus gigas.* Baily, Journ. Roy. Geol. Soc. Ireland, ser. 2, vol. 4, pt. 1, p. 41, pl. 3.
1874. *Palaechinus gigas.* Lovén. Kongl. Svens. Vetens. Akad. Handl., Bd. 11, No. 7, p. 41.
1875. *Palaechinus gigas.* Quenstedt, Petref. Deutschl., p. 380, tab. 75, fig. 40.
1876. *Palaechinus gigas.* Keeping, Quart. Journ. Geol. Soc. Lond., vol. 32, pt. 1, p. 38, pl. 3, figs. 12, 13.
1889. *Palaechinus gigas.* Duncan, Ann. Mag. Nat. Hist., ser. 6, vol. 3, p. 198, fig. 1.
1896. *Palaechinus gigas.* Jackson, Bull. Geol. Soc. Amer., vol. 7, p. 204, pl. 7, figs. 38, 39.
1896. *Palaechinus gigas.* Julien, Terr. Carb. France Centrale, p. 130.

General form orbicular, depressed. Interambulacra composed of six columns of plates. Pores in four rows on each side of the ambulacrum. One adambulacrum plate is as wide as seven ambulacral plates. Tubercles large, each surrounded by a ring. Space between the tubercles smooth.

Geological formation and locality: Carboniferous Limestone, Hook Head, Fethard, Rahan's Bay, Dunkineely, Great Britain; Régny, France.

### 3. Palaechinus intermedius Keeping.

1876. *Palaechinus intermedius.* Keeping, Quart. Journ. Geol. Soc. Lond., vol. 32, pt. 1, p. 37, pl. 3, figs. 9–11.
1889. *Palaechinus intermedius.* Duncan, Ann. Mag. Nat. Hist., ser. 6, vol. 3, p. 203, figs. 9, 10.

Body spheroidal. Interambulacral areas composed of five columns of regular plates, which are uniformly granulated with small tubercles surrounded by a smooth ring each. Ambulacra narrow, composed of wedge-shaped plates granulated like the interambulacral plates. Pores in two series near the outer edge of the plates. Both interambulacral and ambulacral plates imbricate slightly.

Geological formation and locality: Carboniferous, Hook Head, Fethard.

### 4. Palaechinus koninckı M'Coy.

1844. *Palaechinus* (?) *Konigii.* M'Coy, Foss. of Ireland, p. 172, pl. 24, fig. 19.
1850. *Palaechinus Koenigii.* D'Orbigny, Prodrome, vol. 1, p. 154.
1858. *Palaechinus Konigii* (?). Desor, Syn., p. 159.
1862. *Palaechinus Koninckii.* Dujardin et Hupé, Echinodermes, p. 464.
1874. *Palaechinus ? Königi.* Lovén, Kongl. Svens. Vetens. Acad. Handl., Bd. 11, No. 7, p. 41.
1896. *Palaechinus Koninckı.* Julien, Terr. Carb. Marin France Centrale, p. 130, pl. 10, fig. 20; pl. 11, fig. 27.
1897. *Palachinus koninckı.* Tornquist, Abhdl. Geol. Karte Elsass, Bd. 5, Hft. 6, p. 753.

Test composed of numerous plates covered with large compressed tubercles, between which are numerous small tubercles irregularly placed.

Geological formation and locality: Yellow sandstone, Rahan's Bay, Dunkineely; Carboniferous, Régny, Néronde, St. Germain Laval, Central France.

### 5. Palaechinus lacazei Julien.

1890. *Palaechinus Lacazei.* Julien, Compt. rend. Acad. Sci. Paris, T. 110, p. 737.
1896. *Palaechinus Lacazei.* Julien, Terr. Carb. Marin France Centrale, p. 128, pl. 16, figs. 3, 4, 5.
1897. *Palaechinus Lacazei.* Tornquist, Abhdl. Geol. Karte Elsass-Lothr., Bd. 5, Hft. 6, p. 742, taf. 20, figs. 1–4; taf. 21, fig. 1.

Interambulacrum composed of four columns of broad plates which do not imbricate and are covered with numerous small tubercles. Each ambulacral plate has one large tubercle and one pair of pores (?) In the primary plates the pores occupy the outer third of the ambulacrum, while in the secondary plates they are placed on the outer edge of the ambulacrum. Each pair of pores is placed in an oval depression. Ambulacral plates imbricate slightly.

Geological formation and locality: Carboniferous, l'Ardoisière, Central France; Hunsrückenwald, Elsass, Germany.

### 6. Palaechinus sphericus Scouler.

1844. *Palaechinus sphaericus.* Scouler, M'Coy, Foss. of Ireland, p. 172, pl. 24, fig. 5.
1850. *Palaechinus sphaericus.* D'Orbigny, Prodrome, vol. 1, p. 154.
1858. *Palaechinus sphaericus.* Desor, Syn., p. 158.
1862. *Palaechinus sphaericus.* Dujardin et Hupé, Echinodermes, p. 464.
1869. *Palaechinus sphaericus.* De Koninck, Bull. Acad. Bruxelles, ser. 2, vol. 28, p. 546, fig. 1.
1870. *Palaechinus sphaericus.* De Koninck, Geol. Mag., vol. 7, p. 259, pl. 7, fig. 1.
1874. *Palaechinus sphaericus.* Baily, Journ. Roy. Geol. Soc. Ireland, ser. 2, vol. 4, pt. 1, p. 41.
1874. *Palaechinus sphaericus.* Lovén, Kongl. Svens. Vetens. Akad. Handl., Bd. 11, No. 7, p. 41.

1876. *Palaechinus sphaericus.* Keeping, Quart. Journ. Geol. Soc. Lond., vol. 32, pt. 1, p. 38.
1889. *Palaechinus sphaericus.* Duncan, Ann. Mag. Nat. Hist., ser. 6, vol. 3, p. 196, figs. 2–7.
1889. *Typhlechinus sphaericus.* Neumayr, Stämme des Thierreiches Wirbellose, Bd. 1, p. 362.
1892. *Palaechinus sphaericus.* Lohest, Bull. Soc. Geol. Belgique, T. 19, p. 93.
1897. *Palechinus sphaericus.* Tornquist, Abhdl. Geol. Karte Elsass-Lothr., Bd. 5, Hft. 6, p. 738, taf. 21, fig. 3.
1901. *Palaechinus sphericus.* Smith, Fauna, Flora, Geol. Clyde Area, p. 285.
1901. *Palaechinus sphericus.* Hind and Howe, Quart. Journ. Geol. Soc. Lond., vol. 57, p. 352, 355.

General form spherical. Interambulacra consist of six or seven columns each. Ambulacra prominent, convex, with two rows of pores on each side. Surface ornamentation minute tubercles. No ocular plates, the five genital plates forming a closed ring. Four of the genital plates have three pores each, while the fifth has only one.

Geological formation and locality: Carboniferous Limestone, Kirkby-Stephen, Westmoreland.

## UNDETERMINED OR INSUFFICIENTLY DETERMINED SPECIES.

### 1. Palaechinus paradoxus Stuckenberg.

1898. *Palaechinus paradoxus.* Stuckenberg, Allgemeine Geol. Karte Russland, Blatt 27, p. 231, 343.

Geological formation and locality: Carboniferous, Kama Basin, Russia.

### 2. Palaechinus phillipsiae Forbes.

1848. *Palaechinus Phillipsiae.* Forbes, Mem. Geol. Surv. Great Brit., vol. 2, pt. 1, p. 384, tab. 29, fig. 1.
1852. *Palaechinus Phillipsiae.* Roemer, Bronn's Leth. Geog. bd. 1, th. 2, p. 288.
1858. *Palaechinus Phillipsiae.* Desor, Syn., p. 159.

1862. *Palaechinus Phillipsiae.* Dujardin et Hupé, Echinodermes, p. 463.

1874. *Palaechinus Phillipsiae.* Lovén, Kongl. Svens. Vetens. Akad. Handl., bd. 11, no. 7, p. 41.

1875. *Palaechinus Phillipsiae.* Quenstedt, Petref. Deutschl., bd. 3, abth. 1, p. 379, tab. 75, fig. 41.

1889. *Palaechinus Phillipsiae.* Duncan, Ann. Mag. Nat. Hist., ser. 6, vol. 3, p. 203.

Geological formation and locality: Carboniferous, Ireland.

### 3. Palaechinus robineti Julien.

1896. Palaechinus robineti. Julien, Terr. Carb. Marin France Centrale, p. 129, pl. 3, fig. 19b.

Geological formation and locality: Carboniferous, La Varville, Siguret, Central France.

### 4. Palaechinus rutoti Julien.

1896. *Palaechinus Rutoti.* Julien, Terr. Carb. Marin France Centrale, p. 129, pl. 6, fig. 8.

Geological formation and locality: Carboniferous, Savigny, Poil-Fol, France.

### 5. Palaechinus nov. sp. Julien

1874. *Palaechinus nov. sp.* Julien, Compt. Rend. Acad. Sci. Paris, T. 78, p. 76.

Geological formation and locality: Carboniferous, l'Ardoisière, France.

### 6. Palaechinus sp. Mitchell.

1897. *Palaechinus sp.* Mitchell, Proc. Linn. Soc. N. S. W., vol. 22, pt. 2, p. 258.

Geological formation and locality: Upper Silurian, Browning Village, County Harden, New South Wales.

### 7. Palaechinus sp. Tornquist.

1897. *Palaechinus sp.* Tornquist, Abhdl. Geol. Karte Elsass-Lothr., Bd. 5, Hft. 6, p. 763, taf. 20, fig. 6.

Geological formation and locality: Carboniferous, Hunsrückenwald, Elsass, Germany.

## c. Oligoporus Meek and Worthen 1860.*

From five to nine columns of plates in each interambulacrum, and four columns in each ambulacrum. Two pores in each ambulacral plate.

### 1. Oligoporus danae Meek and Worthen.

1860. *Melonites Danae.* Meek and Worthen, Proc. Acad. Nat. Sci. Phil., p. 397.

1860. *Oligoporus Danae.* Meek and Worthen, Proc. Acad. Nat. Sci. Phil., p. 472.

1866. *Oligoporus Danae.* Meek and Worthen, Geol. Surv. Ill., vol. 2, p. 249, pl. 17, fig. 8.

1874. *Oligoporus Danae.* Lovén, Kongl. Svens. Vetens. Akad. Handl., bd. 11, no. 7, p. 42.

1889. *Oligoporus danae.* Miller, N. Amer. Geol. Pal., p. 263, fig. 373.

1894. *Oligoporus danae.* Keyes, Mo. Geol. Surv., vol. 4, p. 126, pl. 17. figs. 2 a, b.

1894. *Oligoporus bellulus.* Miller and Gurley, Bull. No. 3 Ill. State Mus. Nat. Hist., p. 7, pl. 1, fig. 3.

1894. *Oligoporus blairi.* Miller and Gurley, Bull. No. 3 Ill. State Mus. Nat. Hist., p. 6, pl. 1, figs. 2, 6; pl. 2, fig. 7.

1895. *Oligoporus danae.* Keyes, Proc. Iowa Acad. Sci., vol. 2, p. 182, pl. 20, figs. 2 a, b.

1896. *Oligoporus danae.* Jackson, Bull. Geol. Soc. Amer., vol. 7, p. 193, pl. 6, figs. 30–34.

Test large, subglobose. Interambulacral areas lance-ovate,

* Proc. Acad. Nat. Sci. Phil., 1860, p. 474.

composed of nine columns each. Ambulacral areas half as wide as the interambulacral. Pores circular, two to each ambulacral piece, arranged in four vertical rows, the outer rows more or less zigzag. Surface covered with granules, about twenty-five to each larger interambulacral plate.

Geological formation and locality: Keokuk Group, Jersey Co., near Warsaw and Alton, Ill.; Fenton, Curryville and Boonville, Mo.; Keokuk, Iowa.

### 2. Oligoporus coreyi Meek and Worthen.

1870. *Oligoporus Coreyi.* Meek and Worthen, Proc. Acad. Nat. Sci. Phil., p. 34.
1874. *Oligoporus Coreyi.* Lovén, Kongl. Svens. Vetens. Akad. Handl., Bd. 11, No. 7, p. 42.
1889. *Oligoporus Coreyi.* Miller, N. Amer. Geol. Pal., p. 263.
1895. *Oligoporus coreyi.* Keyes, Proc. Iowa Acad. Sci., vol. 2, p. 183.
1896. *Oligoporus coreyi.* Jackson, Bull. Geol. Soc. Amer., vol. 7, p. 186, pl. 6, fig. 25–29.

Body small, globose. Interambulacra twice the width of the ambulacra, composed of six columns each. Interambulacral plates covered with small tubercles. Ambulacral areas quite deeply furrowed. Pores of the ambulacral plates near the outer edge.

Geological formation and locality: Keokuk Group, Crawfordsville, Ind.

### 3. Oligoporus missouriensis Jackson.

1896. *Oligoporus missouriensis.* Jackson, Bull. Geol. Soc. Amer., vol. 7, p. 184, pl. 9, figs. 50–52.

Interambulacral areas composed of six columns each. Interambulacral plates about five times as long as the ambulacral and curving slightly at the junction with the ambulacral. No accessory ambulacral plates. Each ambulacral plate provided with two pores. Ambulacral plates lying opposite the horizontal sutures between the interambulacral plates spread fan-shaped on the outer border.

Geological formation and locality: Augusta Limestone, Webb City, Mo.

### 4. Oligoporus mutatus Keyes.

1894. *Oligoporus mutatus.* Keyes, Mo. Geol. Surv., vol. 4, p. 126, pl. 15, figs. 4 a, b.
1895. *Oligoporus mutatus.* Keyes, Proc. Iowa Acad. Sci., vol. 2, p. 183, pl. 18, figs. 4 a, b.

Test large, spherical. Interambulacral areas broad, composed of five columns of plates each. Ambulacra only about half as wide, very convex, elevated centrally, with shallow bordering furrows. Surface covered with fine spines.

Geological formation and locality: Keokuk Limestone, Keokuk, Iowa.

### 5. Oligoporus nobilis Meek and Worthen.

1868. *Oligoporus nobilis.* Meek and Worthen, Proc. Acad. Nat. Sci. Phil., p. 358.
1873. *Oligoporus nobilis.* Meek and Worthen, Geol. Surv. Ill., vol. 5, p. 476, pl. 11, fig. 3.
1874. *Oligoporus nobilis.* Lovén, Kongl. Svens. Vetens. Akad. Handl., Bd. 11, No. 7, p. 42.
1889. *Oligoporus nobilis.* Miller, N. Amer. Geol. Pal., p. 263.
1895. *Oligoporus nobilis.* Keyes, Proc. Iowa Acad. Sci., vol. 2, p. 182.
1896. *Oligoporus nobilis.* Jackson, Bull. Geol. Soc. Amer., vol. 7, p. 198, pl. 6, fig. 35.

Body large, subglobose. Interambulacra composed of five columns of plates, moderately convex. Ambulacra nearly flat, narrow, lanceolate, not furrowed, about two-thirds as wide as the interambulacral areas. Two pores to each ambulacral piece, forming four double rows. Entire surface ornamented with coarse granules, from forty to sixty to each of the larger interambulacral plates.

Geological formation and locality: Burlington Limestone, Calhoun Co., and Warsaw, Ill.; Keokuk, Iowa.

### 6. Oligoporus parvus. Hambach.

1884. *Oligoporus parvus.* Hambach, Trans. St. Louis Acad. Sci., vol. 4, p. 550, pl. C, fig. 3.
1889. *Oligoporus parvus.* Miller, N. Amer. Geol. Pal., p. 263.
1894. *Oligoporus parvus.* Keyes, Mo. Geol. Surv., vol. 4, p. 127.
1895. *Oligoporus parvus.* Keyes, Proc. Iowa Acad. Sci., vol. 2, p. 183.

Interambulacra composed of five columns of plates each, nearly one-third wider than the ambulacral areas. Ambulacra narrow with an elevated ridge in the center. Each plate has two pores near the outer margin, giving two double rows of pores to each side of the ridge. Plates coarsely granulated and covered with fine short spines.

Geological formation and locality: St. Louis Limestone, St. Louis, Mo., and Hardin Co., Ky.

### insufficiently determined species.

### 1. Oligoporus? minutus Beede.

1899. *Oligoporus? minutus.* Beede, Kas. Univ. Quart., ser. A, vol. 8, no. 3, p. 126, pl. 32, fig. 3.
1900. *Oligoporus? minutus.* Beede, Univ. Geol. Surv. Kas., vol. 6, p. 49, pl. 7, fig. 3.

Geological formation and locality: Deer Creek Limestone, northeast of Topeka, Kas.

## d. Melonites Owen and Norwood 1846.*

Syn. Melonechinus Meek and Worthen 1860.†

Melechinus Quenstedt 1875.‡

From five to nine (sometimes more) columns of plates in each interambulacrum and ten columns in each ambulacrum. Two rows of pores to each ambulacrum.

* Amer. Journ. Sci., ser. 2, vol. 2, p. 225.
† Proc. Acad. Nat. Sci. Phil., p. 396.
‡ Petref. Deutschl., abth. 1, bd. 3, p. 381, pl. 75, figs. 44–50.

### 1. Melonites crassus Hambach.

1884. *Melonites crassus.* Hambach, Trans. St. Louis Acad. Sci., vol. 4, p. 548, pl. C, fig. 1.
1889. *Melonites crassus.* Miller, N. Amer. Geol. Pal., p. 261.
1894. *Melonites crassus.* Keyes, Mo. Geol. Surv., vol. 4, p. 126.
1895. *Melonites crassus.* Keyes, Proc. Iowa Acad. Sci., vol. 2, p. 182.

Body large, globose, composed of very thick plates. Interambulacra lanceolate, moderately convex, with five columns of plates each. Ambulacra twice as wide as the interambulacra, with a very high ridge in the center of each field. Each plate is perforated by two pores. Surface of the ambulacra covered with small spines about $\frac{1}{8}$ inch long, and that of the interambulacra with spines about $\frac{1}{16}$ inch long. From forty-five to sixty-eight may be counted to each of the larger interambulacral plates.

Geological formation and locality: Lower St. Louis Limestone, St. Louis, Mo.

### 2. Melonites dispar Fischer.

1848. *Palaechinus dispar.* Fischer, Bull. Soc. Imp. Moscow, T. 21, p. 243, pl. 3, figs. 4 a–d.
1862. *Palaechinus dispar.* Dujardin et Hupé, Echinodermes, p. 464.
1874. *Melonites dispar.* Lovén, Kongl. Svens. Vetens. Akad. Handl., Bd. 11, no. 7, p. 42.

Body spherical, convex. Pores piercing the ambulacral plates unequal, one being larger than the other. Tubercles very small and few.

Geological formation and locality: Carboniferous Limestone, Ratofka, Moscow, Russia.

### 3. Melonites irregularis Hambach.

1884. *Melonites irregularis.* Hambach, Trans. St. Louis Acad. Sci., vol. 4, p. 549, pl. C, fig. 2.

1889. *Melonites irregularis.* Miller, N. Amer. Geol. Pal., p. 261.

Body globose and very small. Interambulacral areas composed of from five to seven columns of very small and irregular plates. Ambulacra not quite as wide as the interambulacra, with a shallow ridge in the center of each field. Surface ornamented with coarse granules.

Geological formation and locality: Upper St. Louis Limestone, St. Louis, Mo.

### 4. Melonites multiporus Norwood and Owen.

1846. *Melonites multipora.* Norwood and Owen, Amer. Journ. Sci., ser. 2, vol. 2, p. 225, figs. 1–3.
1847. *Melonites multipora.* Engelmann, Amer. Journ. Sci., ser. 2, vol. 3, p. 124.
1850. *Palaechinus multipora.* D'Orbigny, Prodrome, vol. 1, p. 154.
1852. *Melonites multipora.* Roemer, Bronn's Leth. Geog., Bd. 1, Th. 1, p. 288.
1858. *Melonites multipora.* Desor, Syn., p. 159.
1861. *Melonites multipora.* Roemer, Archiv Naturgesch., Jahrg. 21, Bd. 1, p. 312, pl. 12.
1862. *Melonites multipora.* Dujardin et Hupé, Echinodermes, p. 464.
1863. *Palaechinus multipora.* Dana, Man. Geol., p. 313, fig. 536.
1866. *Melonites multipora.* Meek and Worthen, Geol. Surv. Ill., vol. 2, p. 227, figs. 21, 22.
1867. *Palaechinus* (Melonites) *multipora.* Dana, Man. Geol., p. 313, fig. 536.
1869. *Melonites Stewartii.* Safford, Geol. Tenn., p. 346, pl. 6, figs. 1 a–d.
1874. *Melonites multipora.* Lovén, Kongl. Svens. Vetens. Akad. Handl., Bd. 11, No. 7, p. 42.
1875. *Melonites multipora.* Quenstedt, Petref. Deutschl., p. 380, tab. 75, figs. 44–50.
1889. *Melonites multiporus.* Miller, N. Amer. Geol. Pal., p. 261, figs. 364–366.

1894. *Melonites multipora.* Keyes, Mo. Geol. Surv., vol. 4, p. 125, pl. 16, figs. 1 a, b; pl. 17, figs. 1 a–c.
1894. *Melonites indianensis.* Miller and Gurley, Bull. No. 3, Ill. State Mus. Nat. Hist., p. 5, pl. 1, fig. 1.
1894. *Oligoporus sulcatus.* Miller and Gurley, Bull. No. 3, Ill. State Mus. Nat. Hist., p. 8, pl. 1, figs. 4, 5.
1895. *Melonites multipora.* Keyes, Proc. Iowa Acad. Sci., vol. 2, p. 181, pl. 19, figs. 1 a, b; pl. 20, figs. 1 a–c.
1896. *Melonites multiporus.* Jackson and Jaggar, Bull. Geol. Soc. Amer., vol. 7, p. 135, pl. 2, figs. 1–7; pl. 3, figs. 10–17; pl. 4, fig. 18; pl. 5, fig. 20.
1896. *Melonites giganteus.* Jackson, Bull. Geol. Soc. Amer., vol. 7, p. 172, pl. 4, fig. 19; pl. 5, figs. 21–24.

Test large and spherical. Interambulacrum composed of from seven to ten or even more columns of plates. Ambulacrum about two-thirds as wide as the interambulacrum, composed of very irregular plates. Surface covered with numerous small granules, about thirty to each interambulacral plate.

Remarks. After examining a number of specimens as large as that figured by Mr. Jackson as *Melonites giganteus*, and comparing them with specimens of *Melonites multiporus*, I feel that *Melonites giganteus* should be considered an accelerated development of *Melonites multiporus*, and therefore synonymous with it. Its claim to validity rests on its large size and upon the fact that there are ten or eleven columns in each interambulacral area. In a collection of several hundred specimens of *Melonites multiporus* one can find any number with ten, eleven and even twelve columns in one or more interambulacral areas, but which agree in every other essential feature with *Melonites multiporus*.

Geological formation and locality: St. Louis Limestone, St. Louis, Mo.; Clarksville and Charlotte, Tenn.; Greenville, Harrison Co., Indiana; Bowling Green, Ky.

### 5. Melonites septenarius Jackson.

1896. *Melonites septenarius.* Jackson, Bull. Geol. Soc. Amer., vol. 7, p. 182, pl. 9, fig. 49.

Body quite small, wider at the lower end and the sides tapering, giving more of a pear shape to the body. Seven columns of plates in each interambulacrum and only eight in each ambulacrum.

Geological formation and locality: Warsaw Group, Buzzard's Roost, Franklin Co., Ala.

## UNDETERMINED OR INSUFFICIENTLY DETERMINED SPECIES.

### 1. Melonites etheridgii Keeping.

1876. *Melonites Etheridgii.* Keeping, Quart. Journ. Geol. Soc. Lond., vol. 32, pt. 4, p. 398, figs. 1–6.

1896. *Melonites etheridgii.* Jackson, Bull. Geol. Soc. Amer., vol. 7, p. 240.

Mr. Keeping made his description from such fragments that the species' claim to validity does not rest on a firm basis. As Prof. Morris justly remarked in the discussion following the reading of Mr. Keeping's paper, "the specimen was in too imperfect a state of preservation to show whether the valleys described by the author as dividing the ambulacral areas really existed."

Geological formation and locality: Carboniferous, Derbyshire.

### 2. Melonites nov. sp. Julien.

1874. *Melonites nov. sp.* Julien, Compt. Rend. Acad. Sci. Paris, T. 78, p. 76.

Geologicai formation and locality: Carboniferous, L'Ardoisière, France.

### 3. Melonites Tornquist.

1897. *Melonites.* Tornquist, Abhdl. Geol. Karte Elsass, Bd. 5, Hft. 6, p. 763, taf. 20, fig. 7.

Geological formation and locality: Carboniferous, Hunsrückenwald, Elsass, Germany.

## IV. Archaeocidaridae M'Coy 1844.*

Test spherical, more or less compressed or flattened. Never less than four columns of plates in each interambulacrum. Each interambulacral plate is provided with a large tubercle for the attachment of a long spine. Two columns of plates in each ambulacrum, each plate pierced by two pores. Plates imbricate slightly.

### a. Archaeocidaris M'Coy 1844.†

Syn. Echinocrinus Agassiz 1841.‡

Palaeocidaris Desor 1846.§

Each primary tubercle is surrounded by a flat scrobicule and a circlet of granules.

#### 1. Archaeocidaris aculeatus Shumard.

1858. *Archaeocidaris verneuiliana.* Swallow. Trans. St. Louis Acad. Sci., vol. 1, 180.
1858. *Archaeocidaris aculeatus.* Shumard, Trans. St. Louis Acad. Sci., vol. 1, p. 223.
1874. *Archaeocidaris aculeatus.* Lovén, Kongl. Svens. Vetens. Akad. Handl., Bd. 11, No. 7, p. 43.
1889. *Archaeocidaris aculeata.* Miller, N. Amer. Geol. Pal., p. 225.
1894. *Archaeocidaris aculeata.* Keyes, Mo. Geol. Surv., vol. 4, p. 130, pl. 15, fig. 3.
1895. *Archaeocidaris aculeata.* Keyes, Proc. Iowa Acad. Sci. vol. 2, p. 188, pl. 18, fig. 3.

The primary tubercles are small but prominent, situated on an elevated smooth boss with deep circular canal. The

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* Foss. of Ireland, p. 173.
† Foss of Ireland, p. 173.
‡ Monographies des Echinodermes, 2de liv., p. 15.
§ Catalogue raissoné, p. 36.

areola is broad with the exterior margin marked with very obscure radiating striae. Around the areola is a ring of secondary tubercles, succeeded by many fine granules and secondary tubercles.

The primary spines are elongate, fusiform, with strongly curved bases. Some are also slightly curved at the apex. The base ring is small and finely milled. Surface finely striated longitudinally and covered with many short spines set obliquely to the main axis.

Geological position and locality: Middle Permian, west of Council Groves, Kansas; Upper Coal Measures, Verdigris River Valley, and Santa Fé Road; Fort Belknap, Texas; New Point, Jackson County, Missouri.

### 2. Archaeocidaris agassizi Hall.

1858. *Archaeocidaris agassizi.* Hall, Geol. Iowa, vol. 1, pt. 2, p. 698, pl. 26, figs. 1 a–d.
1874. *Archaeocidaris Agassizi.* Lovén, Kongl. Svens. Vetens. Akad. Handl., Bd. 11, No. 7, p. 43.
1889. *Archaeocidaris agassizi.* Miller, N. Amer. Geol. Pal., p. 225, fig. 249.
1894. *Archaeocidaris agassizi.* Keyes, Mo. Geol. Surv., vol. 4, p. 127, pl. 15, fig. 5.
1895. *Archaeocidaris agassizi*, Keyes, Proc. Iowa Acad. Sci., vol. 2, p. 185, pl. 18, fig. 5.
1896. *Archaeocidaris agassizii.* Jackson, Bull. Geol. Soc. Amer., vol. 7, p. 213.
1897. *Archaeocidaris agassizi.* Beede, Trans. Acad. Sci. Kas., vol. 16, p. 77.
1900. *Archaeocidaris agassizi.* Beede, Univ. Geol. Surv., Kas., vol. 6. p. 48, pl. 8, figs. 6–6 e.

Primary tubercle slender, tubuliform, projecting above the surrounding annulation. Deep concavity between the tubercle and the inner edge of the annulation. Distinct annular ridge followed by a depression and a second elevation toward the margin which is ornamented with nodes.

Primary spines, elongated and compressed. Below they

contract and taper gradually toward the summit. Surface of the lower portion smooth; the upper part muricated, having small spiniform tubercles in quincunx order. Point of attachment somewhat elongate. Annulation strongly striated.

Geological formation and locality: Burlington Limestone, Burlington, Iowa; Hannibal, Mo.; Upper Coal Measures, Topeka, Kas.

### 3. Archaeocidaris biangulatus Shumard.

1858. *Archaeocidaris biangulatus.* Shumard, Trans. St. Louis Acad. Sci., vol. 1, p. 224.
1874. *Archaeocidaris biangulata.* Lovén, Kongl. Svens. Vetens. Akad. Handl., bd. 11, no. 7, p. 44.
1889. *Archaeocidaris biangulata.* Miller, N. Amer. Geol. Pal. p., 225.
1894. *Archaeocidaris biangulata.* Keyes, Mo. Geol. Surv., vol. 4, p. 130, pl. 15, figs. 1 a–c.
1895. *Archaeocidaris biangulata.* Keyes, Proc. Iowa Acad. Sci., vol. 2, p. 185, pl. 15, figs. 1 a–c.

Areola subhexagonal, covered with very minute radiating striae, inner ring narrow and prominent.

Primary spines very long and slender, marked with fine longitudinal striae. Immediately above the base the spines are cylindrical, but soon become flattened and angular. The edges are ornamented with short flattened projections, set obliquely to the main axis. The expanded part of the base of the spines is strongly striated.

Geological formation and locality: Middle and Upper Coal Measures, Lexington and Kansas City, Mo.

### 4. Archaeocidaris cratis White.

1876. *Archaeocidaris cratis.* White, Powell's Rep. Geol. Uinta Mts., p. 109.
1880. *Archaeocidaris cratis.* White, Cont. to Inv. Pal., No. 6, p. 130, pl. 33, fig. 2 a.
1889. *Archaeocidaris cratis.* Miller N. Amer. Geol. Pal., p. 225.

1895. *Archaeocidaris cratis.* Keyes, Proc. Iowa Acad. Sci., vol. 2, p. 188.

1903. *Archaeocidaris cratis.* Girty, U. S. Geol. Surv., Professional Paper No. 16, p. 331.

Spines slender, tapering gradually to the apex, ornamented with well defined spinules some distance apart. Basal ring prominent with finely crenulated edges, otherwise plain.

Geological formation and locality: Middle Carboniferous, confluence of the Grand and Green Rivers, Utah; Crested Butte district, Leadville district and Ouray, Colo.

### 5. Archaeocidaris dininni White.

1880. *Archaeocidaris dininni.* White, Proc. U. S. Nat. Mus., vol. 2, p. 260, pl. 1, figs. 13–15.

1880. *Archaeocidaris dininni.* White, Cont. to Inv. Pal., No. 6, p. 131, pl. 35, figs. 6 a–c.

1889. *Archaeocidaris dininni.* Miller, N. Amer. Geol. Pal., p. 225.

1894. *Archaeocidaris dininni.* Keyes, Mo. Geol. Surv., vol. 4, p. 130, pl. 15, figs. 6 a–c.

1895. *Archaeocidaris dininni.* Keyes, Proc. Iowa Acad. Sci., vol. 2, p. 190, pl. 18, figs. 6 a–c.

Primary spines fusiform and strong. Neck short and plain, the rest of the spine studded with many spinules at nearly right angles to the main axis, except near the summit where they stand obliquely upward. Spinules most numerous and strongest near the base. Smaller spines more slender and some without a basal ring.

Geological formation and locality: Upper Coal Measures, near Tecumseh, Neb.; Kansas City, Mo.; Red Oak, Iowa.

### 6. Archaeocidaris edgarensis Worthen and Miller.

1883. *Archaeocidaris edgarensis.* Worthen and Miller, Geol. Surv. Ill., vol. 7, p. 337, pl. 30, figs. 15 a–c.

1889. *Archaeocidaris edgarensis.* Miller, N. Amer. Geol. Pal., p. 225.

1891. *Archaeocidaris edgarensis.* Keyes, Proc. Acad. Nat. Sci. Phil., p. 245.

Primary spines long, cylindrical, tapering gradually. Strongly striated ring at the base. Upper portion of the spines for about three-fourths of their length are set with short lateral spinules pointing upward. Spine terminates in a mucronate point.

Geological formation and locality: Upper Coal Measures, near Baldwinsville, Edgar Co., Ill.; Lower Coal Measures, Des Moines, Iowa.

### 7. Archaeocidaris gracilis Newberry.

1861. *Archaeocidaris gracilis.* Newberry, Ives' Colo. Expl. Exped., pt. 3, p. 117, pl. 1, figs. 4, 4 a.
1874. *Archaeocidaris gracilis.* Lovén, Kongl. Svens. Vetens. Akad. Handl., bd. 11, No. 7, p. 44.
1889. *Archaeocidaris gracilis.* Miller, N. Amer. Geol. Pal., p. 225.

Circle of small tubercles around the primary tubercle, which is deeply perforated. Spines slender, conical, circular in section, set with fine granulations, scattered toward the apex. Basal ring crenulated and prominent.

Geological formation and locality: Upper Carboniferous, Banks of the Colorado River.

### 8. Archaeocidaris illinoisensis Worthen and Miller.

1883. *Archaeocidaris illinoiensis.* Worthen and Miller, Geol. Surv. Ill., vol. 7, p. 338, pl. 31, figs. 1 a–b.
1889. *Archaeocidaris illinoisensis.* Miller, N. Amer. Geol. Pal., p. 225.
1895. *Archaeocidaris illinoisensis.* Keyes, Proc. Iowa Acad. Sci., vol. 2, p. 187.

Primary spines stout, cylindrical, tapering gradually. Articulating ring subangular, just above which the spines are slightly curved. Above this they are studded with short sharp spinules directed outward and slightly upward.

Geological formation and locality: St. Louis Limestone, Hardin Co., Ill.

### 9. Archaeocidaris keokuk Hall.

1858. *Archaeocidaris keokuk.* Hall, Geol. Iowa, vol. 1, pt. 2, p. 699, pl. 26, figs. 2 a, b.
1874. *Archaeocidaris Keokuk.* Lovén, Kongl. Svens. Vetens. Akad. Handl., Bd. 11, No. 7, p. 43.
1889. *Archaeocidaris keokuk.* Miller, N. Amer. Geol. Pal., p. 225.
1894. *Archaeocidaris keokuk.* Keyes, Mo. Geol. Surv., vol. 4, p. 128.
1895. *Archaeocidaris keokuk.* Keyes, Proc. Iowa Acad. Sci., vol. 2, p. 186.

Central tubercle papilliform with a depressed space between it and the annulation. Beyond the annulation is a flattened elevation. Surface between this and the nodulose rim concave.

Primary spines round, muricate, ridged and having spiniform tubercles. Spines expand near the base into a subangular annulation.

Geological formation and locality: Keokuk Limestone, Warsaw, Ill.; Clark Co. and Boonville, Mo.

### 10. Archaeocidaris legrandensis Miller and Gurley.

1890. *Archaeocidaris legrandensis.* Miller and Gurley, 16th Rep. Geol. Surv. Ind., p. 373, pl. 10, fig. 15.
1895. *Archaeocidaris legrandensis.* Keyes, Proc. Iowa Acad. Sci., vol. 2, p. 185.

Primary tubercles large, occupying about half the plate. Annular ring obscure, with a concave depression around it and a distinct elevation toward the margin. Margin studded with obscure nodes.

Primary spines very long, cylindrical and smooth. At the base the spine is contracted a little with a slight swelling immediately above. Spines taper gradually.

Geological formation and locality: Kinderhook Group, Le Grand, Iowa.

### 11. Archaeocidaris longispinus Newberry.

1861. *Archaeocidaris longispinus.* Newberry, Ives' Colo. Expl. Exped., pt. 3, p. 116, pl. 1, fig. 1, 1 a.
1874. *Archaeocidaris longispina.* Lovén, Kongl. Svens. Vetens. Akad. Handl., Bd. 11, no. 7, p. 44.
1889. *Archaeocidaris longispina.* Miller, N. Amer. Geol. Pal., p. 225.
1895. *Archaeocidaris longispinus.* Keyes, Proc. Iowa Acad. Sci., vol. 2, p. 191.

Primary spines elongate, fusiform, cylindrical in section. Surface smooth or finely striated lengthwise. Basal ring small and crenulated slightly. Spines curve slightly above the ring, otherwise straight throughout.

Geological formation and locality: Upper Carboniferous, Banks of the Colorado River.

### 12. Archaeocidaris megastylus Shumard.

1858. *Archaeocidaris megastylus.* Shumard, Trans. St. Louis Acad. Sci., vol. 1, p. 225.
1874. *Archaeocidaris megastylis.* Lovén, Kongl. Svens. Vetens. Akad. Handl., Bd. 11, no. 7, p. 44.
1889. *Archaeocidaris megastylus.* Miller, N. Amer. Geol. Pal., p. 225.
1894. *Archaeocidaris megastylus.* Keyes, Mo. Geol. Surv., vol. 4, p. 129, pl. 15, figs. 2 a, b.
1895. *Archaeocidaris megastylus.* Keyes, Proc. Iowa Acad. Sci., vol. 2, p. 189, pl. 18, figs. 2 a–b.
1900. *Archaeocidaris megastylus.* Beede, Univ. Geol. Surv. Kas., vol. 6, p. 49, pl. 8, fig. 7.

Boss broad and smooth. Areolar surface very broad, slightly concave at the exterior part and surrounded by a row of small secondary tubercles.

Primary spines long, robust, fusiform, very finely striated longitudinally and studded with fine granules or minute short spines. Basal ring oblique to the axis with crenulated border.

Geological formation and locality: Upper Coal Measures,

Headwaters of the Verdigris River and in the valley of the Cottonwood Creek, Kansas; Independence, Mo.

### 13. Archaeocidaris mucronatus Meek and Worthen.

1860. *Archaeocidaris mucronata.* Meek and Worthen, Proc. Acad. Nat. Sci. Phil., p. 395.
1866. *Archaeocidaris mucronata.* Meek and Worthen, Geol. Surv. Ill., vol. 2, p. 295, pl. 23, figs. 3 a–c.
1874. *Archaeocidaris mucronata.* Lovén, Kongl. Svens. Vetens. Akad. Handl., Bd. 11, no. 7, p. 43.
1889. *Archaeocidaris mucronata.* Miller, N. Amer. Geol. Pal., p. 225.
1895. *Archaeocidaris mucronata.* Keyes, Proc. Iowa Acad. Sci., vol. 2, p. 188.

Central tubercle prominent with a distinct annular groove. Primary spines long and tapering with a slight curvature above the articulating extremity. Ring very distinct, smooth, somewhat angular. Spines armed with sharp short lateral spinules directed obliquely outward and upward. Spines marked with very fine obscure longitudinal striae.

Geological formation and locality: Chester Limestone, Liberty, Randolph Co., and Chester, Ill.

### 14. Archaeocidaris nerii Münster.

1840. *Cidarites Nerei.* Münster, Beitr. I., p. 40, tab. 3, figs. 6 a–d.
1840. *Cidarites Protei.* Münster, Beitr. I., p. 40.
1842. *Cidaris Protei.* Koninck, Desc. Ann. Foss., p. 34, tab. E, figs. 1 a–i.
1843. *Cidaris Nerei.* Portlock, Geol. Rep., p. 352.
1847. *Palaeocidaris Nerei.* Desor et Agassiz, Cat. Rais., p. 36.
1847. *Palaeocidaris Protei.* Desor et Agassiz, Cat. Rais., p. 36.
1850. *Echinocrinus Nerei.* D'Orbigny, Prodrome, vol. 1, p. 154.

1850. *Echinocrinus Protei.* D'Orbigny, Prodrome, vol. 1, p. 154.
1854. *Palaeocidaris Nerei.* Vogt, Lehrbuch d. Geol. u. Petref., Aufl. 2, Bd. 1, p. 314.
1858. *Archaeocidaris Nerei.* Desor, Syn., p. 154, tab. 1, fig. 6.
1862. *Archaeocidaris Nerei.* Dujardin et Hupé, Echinodermes, p. 465.
1874. *Archaeocidaris Nerei.* Lovén, Kongl. Svens. Vetens. Akad. Handl., Bd. 11, no. 7, p. 43.
1896. *Archaeocidaris Nerei.* Julien, Terr. Carb. de la France Centrale, p. 126, pl. 6, figs. 6, 7.
1897. *Archaeocidaris Nerei.* Leyh, Zeitsch. Deut. Geol. Gesell., Bd. 49, p. 540.

Ring around each primary tubercle very marked. Scrobicule surrounded by a circle of small radiating ridges instead of granules. Spines cylindrical, sometimes striated, sometimes finely spinous with a tendency to branch near the apex.

Geological formation and locality: Carboniferous, Regnitzlosau and Tournay, Belgium; La Varville and Siguret, France.

### 15. Archaeocidaris newberryi Hambach.

1884. *Archaeocidaris newberryi.* Hambach, Trans. St. Louis Acad. Sci., vol. 4, p. 551, pl. D, fig. 1.
1889. *Archaeocidaris newberryi.* Miller, N. Amer. Geol. Pal., p. 225.
1894. *Archaeocidaris newberryi.* Keyes, Mo. Geol. Surv., vol. 4, p. 129.
1895. *Archaeocidaris newberryi.* Keyes, Proc. Iowa Acad. Sci., vol. 2, p. 187.

Primary tubercle papilliform with a double annulation, and a ring of granules beyond. Spines elongate, slightly compressed toward the summit and bent just above the crenulated annulation. Surface of the spines finely striated and ornamented with small ascending spinules.

Geological formation and locality: St. Louis Limestone, St. Louis, Mo.

### 16. Archaeocidaris norwoodi Hall.

1858. *Archaeocidaris norwoodi.* Hall, Geol. Iowa, vol. 1, pt. 2, p. 701, pl. 26, figs. 5 a–e.
1867. *Archaeocidaris Norwoodi.* Dana, Man. Geol., p. 312, fig. 535.
1874. *Archaeocidaris Norwoodi.* Lovén, Kongl. Svens. Vetens. Akad. Handl. Bd. 11, no. 7, p. 43.
1889. *Archaeocidaris norwoodi.* Miller, N. Amer. Geol. Pal., p. 225.
1894. *Archaeocidaris norwoodi.* Keyes, Mo. Geol. Surv., vol. 4, p. 129.
1895. *Archaeocidaris norwoodi.* Keyes, Proc. Iowa Acad. Sci., vol. 2, p. 188.

Primary tubercles papilliform with thickened sides raised above the annulation. Margin of the annulation thickened, rounded and spreading into a flattened disk. Space between slightly depressed and sometimes having radiating ridges.

Primary spines slender, elongated, slightly curving, longitudinally striated below and muricate above. Fine sharply elevated denticles and short round diverging spinules at intervals along the spines. Intermediate surface granulose.

Geological formation and locality: Kaskaskia Limestone, Chester and Kaskaskia, Ill.; near St. Louis, Mo.

### 17. Archaeocidaris ornatus Newberry.

1861. *Archaeocidaris ornatus.* Newberry, Ives' Colo. Expl. Exped., p. 116, pl. 1, fig. 2, 3, 3 a.
1874. *Archaeocidaris ornata.* Lovén, Kongl. Svens. Vetens. Akad. Handl., Bd. 11, No. 7, p. 44.
1877. *Archaeocidaris ornatus.* White, U. S. Geog. Surv. W. 100 Merid., vol. 4, page 104, pl. 6, fig. 7.
1889. *Archaeocidaris ornata.* Miller, N. Amer. Geol. Pal., p. 225.
1895. *Archaeocidaris ornatus.* Keyes, Proc. Iowa Acad. Sci., vol. 2, p. 191.

1903. *Archaeocidaris ornata.* Girty, U. S. Geol. Surv. Professional Paper No. 16, p. 331.

Primary spines fusiform and strong. For a short distance above the basal ring the surface is plain or not conspicuously marked. Above this it is thickly set with spinules arranged in an imperfect spiral line. Basal rings rather large with crenulated border.

Geological formation and locality: Upper Carboniferous Limestone, Banks of the Colorado River; Ojo del Oso, near Fort Wingate, New Mexico; San Juan region, Leadville district, Colo.

### 18. Archaeocidaris rossicus von Buch.

1842. *Cidaris Rossicus.* von Buch, Karsten's Archiv, Bd. 16, p. 523.

1845. *Cidarites Rossicus.* Murchison, Verneuil, Keyserling, Geol. Russ. d'Europe, vol. 2, p. 16, 396,pl. 1, figs. 2 a–e.

1847. *Palaeocidaris Rossica.* Desor et Agassiz, Cat. Rais., p. 36.

1850. *Echinocrinus Rossica.* D'Orbigny, Prodrome, vol. 1, p. 154.

1854. *Palaeocidaris rossica.* Vogt, Lehrbuch d. Geol. u. Petref., 2 Aufl., Bd. 1, p. 314.

1858. *Eocidaris Rossica.* Desor, Syn., p. 156, pl. 21, figs. 3–6.

1860. *Echinocrinus Duecalionis.* Eichwald, Leth. Ross., T. 1, p. 652.

1860. *Echinocrinus ornatus.* Eichwald, Leth. Ross., T. 1, p. 654, tab. 32, fig. 24.

1862. *Eocidaris rossica.* Dujardin et Hupé, Echinodermes, p. 467.

1866. *Eocidaris Rossicus.* Geinitz, Carb. u. Dyas in Nebr., p. 61.

1868. *Archaeocidaris rossicus.* Trautschold, Bull. Soc. Nat. Moscou, vol. 41, p. 467, pl. 9.

1874. *Archaeocidaris rossica.* Lovén, Kongl. Svens. Vetens. Akad. Handl., bd. 11, no. 7, p. 43.

1879. *Archaeocidaris rossica.* Trautschold, Nouv. Mém. Soc. Imp. Nat. Moscou, t. 14, liv. 1, p. 5, tab. 2, figs. 1 a–e.

1896. *Archaeocidaris rossica.* Tornquist. Neu. Jahrb. Miner. Geol. u. Pal., bd. 2, p. 27, taf. 4, figs. 1–8.

1900. *Archaeocidaris rossica.* Hesse, Neu. Jahrb. Miner. Geol. u. Pal., beil.-bd. 13, p. 213.

Scrobicule large, embracing nearly the whole plate. Edges ornamented with small granules. Spines large with smooth ring and covered with fine granules not arranged in series.

Geological formation and locality: Subcarboniferous: Paskra, Staritza, Ivanof, Utega, Kopocheva, Kosimol, Mjatchkova Podolesk, Russia.

### 19. Archaeocidaris shumardanus Hall.

1858. *Archaeocidaris shumardana.* Hall, Geol. Iowa, vol. 1, pt. 2, p. 699, pl. 26, figs. 3 a–d.

1867. *Archaeocidaris Shumardana.* Dana, Man. Geol., p. 312, fig. 534.

1874. *Archaeocidaris shumardana.* Lovén, Kongl. Svens. Vetens. Akad. Handl. bd. 11, no. 7, p. 43.

1884. *Archaeocidaris* cf. *Shumardana.* Walcott, Pal. Eureka Dist., p. 212.

1889. *Archaeocidaris shumardana.* Miller, N. Amer. Geol. Pal., p. 225.

1894. *Archaeocidaris shumardana.* Keyes, Mo. Geol. Surv., vol. 4, p. 128.

1895. *Archaeocidaris shumardiana.* Keyes, Proc. Iowa Acad. Sci., vol. 2, p. 186.

Primary tubercles papilliform with a deep space between the tubercle and the annulation. Annulation has an abrupt upper margin, swelling out below into a convex rim. Surface between this rim and the elevated nodose margin is abruptly concave. Primary spines short, smooth or finely striated near the base, otherwise muricate with ascending nodes.

Geological formation and locality: Warsaw Limestone, Warsaw, Ill.; Lower Carboniferous, Eureka District, Nevada; Keokuk Limestone, La Grange, Mo.

20. Archaeocidaris spinoclavatus Worthen and Miller.

1873. *Archaeocidaris?* (*sp. undet*). Meek and Worthen, Geol. Surv. Ill., vol. 5, pl. 24, figs. 13 a–e.
1883. *Archaeocidaris spinoclavatus.* Worthen and Miller, Geol. Surv. Ill., vol. 7, p. 337, pl. 30, figs. 14 a–e.
1889. *Archaeocidaris spinoclavata.* Miller, N. Amer. Geol. Pal., p. 225.
1895. *Archaeocidaris spinoclavatus.* Keyes, Proc. Iowa Acad. Sci., vol. 2, p. 190.

Primary spines long, stout, cylindrical at the base, growing larger gradually toward the apex and abruptly diminishing to an obtuse clavate end. The upper end of the spine is thickly covered with nodose spinules directed upward. On the remaining part of the spine the spinules are smaller and fewer in number. Basal ring smooth.

Geological formation and locality: Coal Measures, St. Clair and Marshall Cos., Ill.

21. Archaeocidaris triplex White.

1881. *Archaeocidaris triplex.* White, U. S. Geog. Geol. Surv. W. 100th Mer., vol. 3, Supp. Appendix, p. xxii., pl. 4, figs. 3 a–c.
1889. *Archaeocidaris triplex.* Miller, N. Amer. Geol. Pal., p. 225.
1895. *Archaeocidaris triplex.* Keyes, Proc. Iowa Acad. Sci., vol. 2, p. 191.
1903. Archaeocidaris triplex? Girty, U. S. Geol. Surv., Professional Paper No. 16, p. 330.

Areolar surface plain or having only a single circle between the primary tubercle and the outer border. Primary tubercle small and surrounded by a prominent border.

Primary spines large, strong, subtriangular and spinulose. Spinules stout, short and prominent, rather far apart in three rows from a short distance above the base. Basal ring prominent and finely crenulated at the edge.

Geological formation and locality: Upper Coal Measures, New Mexico, San Juan region, Needle Mountains quadrangle.

### 22. Archaeocidaris triserialis M'Coy.

1844. *Echinocrinus triserialis.* M'Coy, Foss. of Ireland, p. 173, pl. 26, fig. 1.
1850. *Echinocrinus triserialis.* D'Orbigny, Prodrome, vol. 1, p. 154.
1858. *Archaeocidaris triserialis.* Desor, Syn., p. 155.
1862. *Archaeocidaris triserialis.* Dujardin et Hupé, Echinodermes, p. 466.
1874. *Archaeocidaris triserialis.* Lovén, Kongl. Svens. Vetens. Akad. Handl., Bd. 11, no. 7, p. 43.

Spines large ornamented with three angular ridges. Each ridge is ornamented with tooth-like spines. Space intervening smooth.

Geological formation and locality: Subcarboniferous, Ireland.

### 23. Archaeocidaris triserratus Meek.

1872. *Archaeocidaris ? triserrata.* Meek, U. S. Geol. Surv. Neb., p. 151, pl. 1, figs. 6 a — c.
1889. *Archaeocidaris triserrata.* Miller, N. Amer. Geol. & Pal., p. 225.
1895. *Archaeocidaris triserrata.* Keyes, Proc. Iowa Acad. Sci., vol. 2, p. 190.

Primary spines slender, a little arched near the base. Spines cylindrical near the base but compressed rhombic further up. Margins sharp and serrated. On the middle concave side of the curvature of the spine there is a third serrated row, extending from the base about two-thirds of the way. On the other side three or four rows of smaller granules run from the base to about the middle. Ring at the base faintly milled. Articulating extremity contracting abruptly and finely striated.

Geological formation and locality: Upper Coal Measures, Omaha, Nebraska City, and three miles above the mouth of

the Platte River, Neb.; Vermilion Co., Ill., and Kansas City, Mo.

### 24. Archaeocidaris trudifer White.

1874. *Archaeocidaris trudifer.* White, Prelim. Rep. Inv. Foss., p. 17.
1876. *Archaeocidaris trudifer.* White, Powell's Rep. Geol. Uinta Mts., p. 89.
1877. *Archaeocidaris trudifer.* White, U. S. Geol. Surv. W. 100 Mer., vol. 4, p. 104, pl. 6, figs. 8 a, b.
1889. *Archaeocidaris trudifera.* Miller, N. Amer. Geol., p. 225.
1895. *Archaeocidaris trudifer.* Keyes, Proc. Iowa Acad. Sci., vol. 2, p. 191.
1900. *Archaeocidaris trudifer.* Beede, Univ. Geol. Surv. Kas., vol. 6, p. 47, pl. 8, fig. 10.
1903. *Archaeocidaris trudifer* ? Girty, U. S. Geol. Surv. Professional Paper No. 16, p. 330.

Areolar surface plain. Central tubercle small, surrounded by a slightly raised ring and a second ring so much elevated as to form a little cup with an expanded rim.

Primary spines slender and terete, tapering gradually near the apex. Surface of the spine immediately above the basal ring smooth, but further on ornamented with numerous fine spinules in an imperfect spiral.

Geological formation and locality: Coal measures, Camp Apache, Arizona; Confluence of the Grand and Green rivers, Utah; Topeka, Kas.; Leadville district, Colo.

### 25. Archaeocidaris urei Fleming.

1793. *Echinus* ——. Ure, Hist. Rutherglen, pl. 16, figs. 7, 8.
1828. *Cidaris Urii.* Fleming, Brit. Animals, p. 478.
1843. *Cidaris Benburbensis.* Portlock, Geol. Rep., p. 352, pl. 16, figs. 10a–d.
1844. *Echinocrinus Urii.* M'Coy, Foss. of Ireland, p. 174, pl. 27, fig. 1.

1850. *Echinocrinus Urii.* D'Orbigny, Prodrome, vol. 1, p. 154.
1852. *Archaeocidaris Urii.* Roemer, Leth. Geog., Bd. 1, Th. 2, p. 288, taf. 41, fig. 2.
1854. *Archaeocidaris Urii.* Morris, Cat. Brit. Foss., p. 72.
1858. *Archaeocidaris Urii.* Desor, Syn., p. 154, tab. 21, figs. 11, 12.
1862. *Archaeocidaris Urii.* Dujardin et Hupé, Echinodermes, p. 465.
1874. *Archaeocidaris Urii.* Julien, Compt. Rend. Acad. Sci. Paris, T. 78, p. 76.
1874. *Archaeocidaris Urei.* Lovén, Kongl. Svens. Vetens. Akad. Handl., Bd. 11, no. 7, p. 43.
1875. *Archaeocidaris Urii.* Baily, Char. Brit. Foss., p. lxviii, pl. 36, figs. 12 a, b.
1876. *Archaeocidaris Urii.* Keeping, Quart. Journ. Geol. Soc. Lond., vol. 32, pt. 1, p. 39, pl. 3, figs. 14–18.
1890. *Archaeocidaris Urii.* Julien, Compt. Rend. Acad. Sci. Paris, T. 110, p. 737.
1893. *Archaeocidaris Urii.* Tornquist, Mitth. Geol. Landes-Anst. Elsass-Lothr., Bd. 4, hft. 2, p. 102.
1895. *Archaeocidaris urei.* Neilson, Trans. Geol. Soc. Glasgow, vol. 10, p. 77, fig. 3.
1896. *Archaeocidaris Urii.* Julien, Terr. Carb. Marin de la France Centrale, p. 123.
1897. *Archaeocidaris Urii.* Tornquist, Abhdl. Geol. Karte Elsass-Lothr. Bd. 5, hft. 6, p. 775, taf. 22, figs. 4, 5, 6, 7, 11.
1898. *Archaeocidaris urei.* Thomson, Trans. Geol. Soc. Glasgow, vol. 11, p. 24, 26, 30.

Ring at the base of the primary tubercle very distinct. Edges of the plates bearing tubercles ornamented with radiating ridges.

Primary spines long, finely striated about one-third of the way, the upper part ornamented by five or six ranges of longitudinal alternating rows of short stout spines.

Geological formation and locality: Carboniferous Limestone, Townparks Killeshandra; Lough Esk, Donegal; Ra-

han's Bay and St. John's Point, Dunkineely; Malahide, Malahide; l'Ardoisière, France; Hunsrückenwald, Ober-Elsass.

### 26. Archaeocidaris vetustus Phillips.

1836. *Cidaris vetusta.* Phillips, Geol. Yorkshire, p. 208.
1843. *Cidaris vetusta.* Portlock, Geol. Rep., p. 353, pl. 16, fig. 11.
1844. *Echinocrinus vetusta.* M'Coy, Foss. of Ireland, p. 174.
1862. *Archaeocidaris vetusta.* Dujardin et Hupé, Echinodermes, p. 466.
1874. *Archaeocidaris vetusta.* Lovén, Kongl. Svens. Vetens. Akad. Handl., Bd. 11, no. 7, p. 43.

Ring at the base of the spine sharp and strongly milled. Spines tapering with strong prickles which alternate. No longitudinal striae. Prickles separated considerably. Plates have a simple border of granules.

Geological formation and locality: Carboniferous Limestone, Florence Court, Ravenstonedale, Northumberland; Coalbrookdale, Whitewell; Hook Head, Fethard; Tyrone; Fermanagh.

### 27. Archaeocidaris wortheni Hall.

1858. *Archaeocidaris wortheni.* Hall, Geol. Iowa, vol. 1, pt. 2, p. 700, pl. 26, figs. 4 a–g.
1867. *Archaeocidaris wortheni.* Dana, Man. Geol., p. 312, fig. 533.
1874. *Archaeocidaris Wortheni.* Lovén, Kongl. Svens. Vetens. Akad. Handl., Bd. 11, no. 7, p. 43.
1875. *Archaeocidaris Wortheni.* Quenstedt, Petref. Deutschl., Bd. 3, Abth. 1, p. 372, tab. 75, fig. 10.
1884. *Archaeocidaris* cf. *wortheni.* Walcott, Pal. Eureka Dist., p. 212.
1889. *Archaeocidaris wortheni.* Miller, N. Amer. Geol. Pal., p. 225.
1894. *Archaeocidaris wortheni.* Keyes, Mo. Geol. Surv., vol. 4, p. 128, pl. 16, figs. 3 a, b.

1895. *Archaeocidaris wortheni.* Keyes, Proc. Iowa Acad. Sci., vol. 2, p. 187, pl. 20, figs. 3 a, b.
1896. *Archaeocidaris wortheni.* Jackson, Bull. Geol. Soc. Amer., vol. 7, p. 214, pl. 8, figs. 43–46.
1897. *Archaeocidaris Wortheni.* Tornquist, Abhdl. Geol. Karte Elsass-Lothr., Bd. 5, hft. 6, p. 770, taf. 21, fig. 5.

Primary tubercle papilliform, moderately elevated above the annulation. Annulation thickened and spreading into a slightly elevated disc. Margin denticulated.

Primary spines slender, elongate, slightly curved, smooth or finely granulated. Articulating end expanded into a crenulated annulation and then contracted abruptly below.

Geological formation and locality: St. Louis Limestone, near St. Louis, Mo.; Eureka District, Nevada.

## UNDETERMINED OR INSUFFICIENTLY DETERMINED SPECIES.

### 1. Archaeocidaris glabrispina Philipps.

1836. *Cidaris glabrispina.* Philipps, Geol. Yorkshire, vol. 2, p. 208.
1844. *Echinocrinus glabrispina.* M'Coy, Foss. of Ireland, p. 173.
1862. *Archaeocidaris glabrispina.* Dujardin et Hupé, Echinodermes, p. 466.
1874. *Archaeocidaris glabrispina.* Lovén, Kongl. Svens. Vetens. Akad. Handl., bd. 11, no. 7, p. 43.

Geological formation and locality: Subcarboniferous, Ireland.

### 2. Archaeocidaris grüneri Julien.

1896. *Archaeocidaris grüneri.* Julien, Terr. Carb. Marin de la France Centrale, p. 125, pl. 16, figs. 11, 12.

Geological formation and locality: Carboniferous, l'Ardoisière, France.

### 3. Archaeocidaris koninckı Desor.

1858. *Archaeocidaris Koninckii.* Desor, Syn., p. 155, tab. 21, figs. 7–10.
1862. *Archaeocidaris Koninckii.* Dujardin et Hupé, Echinodermes, p. 465.
1874. *Archaeocidaris Koninckı.* Lovén, Kongl. Svens. Vetens. Akad. Handl., bd. 11, no. 7, p. 43.

Geological formation and locality: Subcarboniferous, Tournay.

### 4. Archaeocidaris ladina Stacke.

1877. *Archaeocidaris ladina.* Stacke, Jahrb. K. K. Geol. Reichsanstalt Wien, bd. 27, p. 318, taf. 1, figs. 11, 12.

Geological formation and locality: Bellerophonkalk, Südtirol.

### 5. Archaeocidaris ourayensis Girty.

1903. *Archaeocidaris ourayensis.* Girty, Professional Paper U. S. Geol. Surv., no. 16, p. 329, pl. 1, fig. 14.

Geological formation and locality: Hermosa formation, Ouray, Colo.

### 6. Archaeocidaris priscus Münster.

1840. *Cidarites priscus.* Münster, Beitr. 1, p. 41.
1847. *Palaeocidaris prisca.* Desor et Agassiz, Cat. Rais., p. 36.
1850. *Echinocrinus prisca.* D'Orbigny, Prodrome, vol. 1, p. 154.
1858. *Archaeocidaris prisca.* Desor, Syn., p. 155.
1862. *Archaeocidaris prisca.* Dujardin et Hupé, Echinodermes, p. 465.
1874. *Archaeocidaris prisca.* Lovén, Kongl. Svens. Vetens. Akad. Handl., bd. 11, no. 7, p. 43.

Geological formation and locality: Subcarboniferous, Regnitzlosau.

### 7. Archaeocidaris rossica M. V. K. var. Schellwieni Tornquist.

1897. *Archaeocidaris rossica M. V. K. var. Schellwieni.* Tornquist, Abhdl. Geol. Karte Elsass-Lothr, Bd. 5, Hft. 6, p. 781, taf. 22, fig. 12.

Geological formation and locality: Upper Carboniferous, Pontafel.

### 8. Archaeocidaris scotica Smith.

1901. *Archaeocidaris scotica.* Smith, Fauna Flora and Geol. Clyde Area, p. 509.

Geological formation and locality: Carboniferous, Clyde Area.

### 9. Archaeocidaris ? selwyni Etheridge, Jr.

1892. *Archaeocidaris ? Selwyni.* Etheridge, Jr., Mem. Geol. Surv. N. S. W., Pal. No. 5, pt. 2, p. 67, pl. 15, figs. 1–3.

Geological formation and locality: Nowra Grit = (Muree Rock of Hunter River Coalfield) Upper Marine Series, Nowra, Shoalhaven River, St. Vincent Co.

### 10. Archaeocidaris tennesseae Troost.

1850. *Cidarites Tenesseae.* Troost, Proc. Amer. Assoc. Adv. Sci., Cambridge Meeting, p. 59.

1874. *Archaeocidaris ? Tenesseae.* Lovén, Kongl. Svens. Vetens. Akad. Handl. Bd. 11, no. 7, p. 44.

Geological formation and locality: Carboniferous, Tennessee.

### 11. Archaeocidaris tirolensis Stacke.

1876. *Archaeocidaris tirolensis.* Stacke, Verhdl. K. K. Geol. Reichsanstalt Wien, Jahrg. 1876, p. 260.

Geological formation and locality: Bellerophonkalke, Südtirol.

12. Archaeocidaris trautscholdi Tornquist.

1896. *Archaeocidaris trautscholdi.* Tornquist, N. Jahrb. Miner. Geol. Pal., Bd. 2, p. 29, taf. 4.

Geological formation and locality: Carboniferous Limestone, Mjatschkowa, Russia.

13. Archaeocidaris wervekei Tornquist.

1897. *Archaeocidaris wervekei.* Tornquist, Abhdl. Geol. Karte, Elsass-Lothr., Bd. 5, Hft. 6, p. 778, pl. 21, fig. 4; taf. 22, figs. 1, 2, 3, 9, 10.

Geological formation and locality: Lower Carboniferous Limestone, Hunsrückenwald, Ober-Elsass, Germany.

14. Archaeocidaris sp. ind. Etheridge, Jr.

1892. *Archaeocidaris sp. ind.* Etheridge, Jr., Mem. Geol. Surv. N. S. W. Pal., No. 5, pt. 2, p. 69, pl. 22, fig. 1.

Geological formation and locality: Upper Marine Series, Dagworth five miles south of West Maitland, Co. Northumberland.

15. Archaeocidaris sp. Etheridge, Jr.

1892. *Archaeocidaris sp.* Etheridge, Jr., Geol. and Pal. Queensland and New Guinea, p. 213.

Geological formation and locality: Gympie Beds, Queensland.

16. Archaeocidaris sp.? Julien.

1896. *Archaeocidaris sp.?* Julien, Le Terr. Carb. Marin de la France Centrale, p. 127, pl. 8, fig. 1.

Geological formation and locality: Carboniferous, Régny, France.

17. Archaeocidaris Julien.

1896. *a. Radioles à 4 rangées d'épines.* Julien, Le Terr. Carb. Marin de la France Centrale, p. 126, pl. 16, figs. 14, 17.

Geological formation and locality: Carboniferous, l'Ardoisière, France.

18. Archaeocidaris Julien.

1896. *b. Radioles à 6 rangées d'épines.* Julien, Le Terr. Carb. de la France Centrale, p. 126, pl. 16, figs. 13, 15, 16; pl. 17, fig. 9.

Geological formation and locality: Carboniferous, l'Ardoisière, France.

19. Archaeocidaris —— ? Meek and Hayden.

1859. *Archaeocidaris* —— ? Meek and Hayden, Proc. Acad. Nat. Sci. Phil., p. 25.

Geological formation and locality: Upper Coal Measures, Cottonwood Creek, Kansas.

20. Archaeocidaris —— ? Meek and Hayden.

1859. *Archaeocidaris* —— ? Meek and Hayden, Proc. Acad. Nat. Sci. Phil., p. 25.

Geological formation and locality: Upper Coal Measures, Cottonwood Creek and Manhattan, Kansas.

21. Archaeocidaris sp. Stacke.

1877. *Archaeocidaris sp.* Stacke, Jahrb. K. K. Geol. Reichsanstalt Wien, bd. 27, p. 318, taf. 1, figs. 13–17.

Geological formation and locality: Bellerophonkalk, Südtirol.

### b. Eocidaris Desor 1858.*

Like *Archaeocidaris* only the primary tubercle has no halo.

#### 1. Eocidaris blairi Miller.

1891. *Eocidaris blairi.* Miller, Adv. Sheets 17th Rep. Geol. Surv. Ind., p. 73, pl. 12, figs. 1, 2.
1892. *Eocidaris blairi.* Miller, 17th Rep. Geol. Surv. Ind., p. 683, pl. 12, figs. 1, 2.

Central tubercle large and perforated. Space between the central tubercle and the marginal tubercles concave.

Primary spines long, tapering gradually, compressed slightly. Articulating end somewhat enlarged. Surface of the spines finely granular. Secondary spines very small.

Geological formation and locality: Keokuk Group, Boonville, Mo.

#### 2. Eocidaris forbesianus De Koninck.

1863. *Cidaris Forbesiana.* De Koninck, Quart. Journ. Geol. Soc. Lond., vol. 19, p. 4, pl. 4, figs. 1, 2.
1863. *Cidaris forbesiana.* De Koninck, Foss. Pal. de l'Inde, p. 22, pl. 3, figs. 1, 2.
1885. *Eocidaris forbesiana.* Waagen, Mem. Geol. Surv. India, ser. 13, vol. 1, p. 819, pl. 95, fig. 5–16.

Primary tubercle large with a high neck and a deeply crenulated collar. Scrobicule large and smooth, surrounded by a narrow margin of rather large distant secondary tubercles.

Primary spines rather flat on one side, tapering distinctly toward the articulating end. Head thick with a very prominent ring, which is crenulated.

Geological formation and locality: Productus Limestone, Kalta, Golawáli, Chidru and in the Bazárwán, India.

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* Synopsis des Échinides Fossiles, p. 155.

### 3. Eocidaris hallianus Geinitz.

1866. *Eocidaris Hallianus.* Geinitz, Carb. u. Dyas in Neb., p. 61, tab. 5, figs. 1 a, b, 2 a, b.
1872. *Eocidaris Hallianus.* Meek, U. S. Geol. Surv. Neb., p. 152, pl. 7, figs. 9 a–d.
1889. *Eocidaris Hallanus.* Miller, N. Amer. Geol. Pal., p. 242.
1894. *Archaeocidaris hallianus.* Keyes, Mo. Geol. Surv., vol. 4, p. 129.
1895. *Archaeocidaris hallianus.* Keyes, Proc. Iowa Acad. Sci., vol. 2, p. 190.
1903. *Eocidaris halliana?* Girty, U. S. Geol. Surv. Professional Paper No. 16, p. 332.

Around the primary tubercle is an irregular ring of perforated nodules, some of which are surrounded by small granules.

Primary spines have a prominent ring near the base. Spines finely striated and curved near the apex. Small spinules, projecting from the spines.

Geological formation and locality: Upper Coal Measures, Nebraska City. Neb.; Kansas City, Mo.; Leadville and Crested Butte district, Colo.

### 4. Eocidaris keyserlingi Geinitz.

1848. *Cidaris Keyserlingi.* Geinitz, Verstein. des Zechstein Gebirges, I, p. 16, pl. 7, figs. 1, 2.
1858 *Eocidaris Kaiserlingii.* Desor, Syn., p. 155, tab. 21, figs. 15, 16.
1861. *Eocidaris Keyserlingi.* Geinitz, Anim. Uebereste der Dyas, I, p. 108, pl. 20, figs. 5–9.
1862. *Eocidaris Kaiserlingii.* Dujardin et Hupé, Echinodermes, p. 467.
1874. *Eocidaris Keyserlingi.* Lovén, Kongl. Svens. Vetens. Akad. Handl., bd. 11, no. 7, p. 42.
1887. *Eocidaris Keyserlingi.* Kolesch, Jena. Zeitschr. f. Naturwiss., bd. 20, p. 5, taf. 38, figs. 4–19.

1892. *Eocidaris Keyserlingi.* Geinitz, Mitth. Osterlande Naturforsch. Gesell. Altenburg, N. F., bd. 5, p. 178.
1897. *Eocidaris Keyserlingi.* Spandel, Abhdl. Naturhist. Gesell. Nürnberg, bd. 11, p. 33, taf. 13, figs. 1–6.
1900. *Eocidaris Keyserlingi.* Hesse, Neu. Jahrb. Miner. Geol. u. Pal., beil. bd. 13, p. 213.

Tubercles very small in proportion to their scrobicules and distinctly perforated. No trace of crenulation.

Primary spines apparently smooth, but in reality very finely striated. Spines swell abruptly at the base into a basal ring. A second kind of spine is broad with two sharp edges which are armed with sharp spinules directed upward. Very small secondary spines also found by Spandel.*

Geological formation and locality: Unteren Zechstein, Corbussen and Röpsen, duchy of Altenburg, Germany.

### 5. Eocidaris laevispinus Sandberger.

. *Cidaris laevispina.* Sandberger, Verst. Rhein. Schichtensystems, p. 382, pl. 35, fig. 2.
1858. *Eocidaris laevispina.* Desor, Syn., p. 156, tab. 21, figs. 18–21.
1862. *Eocidaris laevispina.* Dujardin et Hupé, Echinodermes, p. 467.
1874. *Eocidaris laevispina.* Lovén, Kongl. Svens. Vetens. Akad. Handl., Bd. 11, no. 7, p. 43.

Primary spines cylindrical and ornamented with about twenty-three longitudinal ribs. These ribs are muricated oppositely.

Geological formation and locality: Devonian, Villmar, duchy of Nassau.

### 6. Eocidaris münsterianus De Koninck.

1842. *Echinocrinus Münsterianus.* De Koninck, Desc, Anim. Foss. Carb. Belge, p. 35, pl. E, figs. 2 a–d.

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* Abhdl. Naturhist. Gesell. Nürnberg, Bd. 11, p. 37.

1844. *Echinocrinus Munsterianus?* M'Coy, Foss. of Ireland, p. 173, pl. 27, fig. 2.
1847. *Cidaris Münsteriana.* Desor et Agassiz, Cat. Raiss., p. 25.
1850. *Cidaris Münsteriana.* D'Orbigny, Prodrome, vol. 1, p. 154.
1858. *Eocidaris Münsterianus.* Desor, Syn., p. 156.
1862. *Eocidaris Munsterianus.* Dujardin et Hupé, Echinodermes, p. 468.
1869. *Lepidocentrus Münsterianus.* De Koninck, Bull. Soc. Roy. Bruxelles, ser. 2, vol. 28, pt. 2, p. 546.
1870. *Lepidocentrus Münsterianus.* De Koninck, Geol. Mag., vol. 7, p. 260.
1874. *Archaeocidaris Münsteriana.* Lovén, Kongl. Svens. Vetens. Akad. Handl., bd. 11, no. 7, p. 43.
1897. *Archaeocidaris* cf. *Münsterianus.* Leyh, Zeitsch. Deut. Geol. Gesell., bd. 49, p. 541.
1900. *Eocidaris Münsteriana.* Hesse, Neu. Jahrb. f. Miner. Geol. u. Pal. beil. bd. 13, p. 213.

Primary spines cylindrical and ornamented with a great many denticulated spinules.

Geological formation and locality: Carboniferous, Ireland and Belgium.

### 7. Eocidaris verneuilianus King.

1844. *Cidaris* ——. De Verneuil, Bull. Soc. Geol. France, ser. 2, vol. 1, p. 25.
1845. *Cidaris* ——. Murchison, Verneuil, Keyserling, Geol. Russ. d'Europe, vol. 1, p. 221.
1848. *Cidaris Verneuiliana.* King, Catalogue, p. 6, 7.
1848. *Cidaris Verneuiliana.* Howse, Trans. Tyneside Nat. Field Club, vol. 1, p. 261.
1850. *Archaeocidaris Verneuiliana.* King, Mon. Perm. Foss., p. 53, pl. 6, figs. 22–24.
1858. *Eocidaris Verneuillana.* Desor, Syn., p. 156, tab. 21, figs. 13, 14.
1862. *Eocidaris Verneuillana.* Dujardin et Hupé, Echinodermes, p. 467.

1874. *Eocidaris Verneuiliana.* Lovén, Kongl. Svens. Vetens. Akad. Handl., Bd. 11, no. 7, p. 43.

Spines perforated and placed on elevated bases. Basal ring crenulated radiately. Plates have a concave depression, surrounded by an elliptical border of small tubercles in a single series. Two kinds of spines known — one, muricated and the other, striated longitudinally.

Geological formation and locality: Shell-Limestone, Tunstall Hill and Humbleton Quarry.

## UNDETERMINED OR INSUFFICIENTLY DETERMINED SPECIES.

### 1. Eocidaris drydenensis Vanauxem.

1842. *Echinus drydenensis.* Vanauxem, Rep. Third Geol. Dist., p. 184.
1867. *Eocidaris Drydenensis.* Hall, 20th Rep. State Cab. Nat. Hist. New York, p. 298.
1874. *Eocidaris drydenensis.* Lovén, Kongl. Svens. Vetens. Akad. Handl., bd. 11, no. 7, p. 43.
1889. *Eocidaris drydenensis.* Miller, N. Amer. Geol. Pal., p. 242.
1895. *Archaeocidaris drydenensis.* Keyes, Proc. Iowa Acad. Sci., vol. 2, p. 184.
1896. *Archaeocidaris drydenensis.* Jackson, Bull. Geol. Soc. Amer., vol. 7, p. 214.

Geological formation and locality: Devonian, Chemung Sandstone, Dryden, New York.

### 2. Eocidaris scrobiculata Sandberger.

*Cidaris scrobiculata.* Sandberger, Verst. Rhein. Schichtensystems, p. 382, pl. 35, fig. 3.
1858. *Eocidaris scrobiculata.* Desor, Syn., p. 157, tab. 21, fig. 17.
1862. *Eocidaris scrobiculata.* Dujardin et Hupé, Echinodermes, p. 467.

1874. *Eocidaris scrobiculata.* Lovén, Kongl. Svens. Vetens. Akad. Handl., bd. 11, no. 7, p. 43.

Geological formation and locality: Devonian, Villmar duchy of Nassau.

3. Eocidaris sp. ind. Julien.

1874. *Eocidaris sp. ind.* Julien, Compt. Rend. Acad. Sci. Paris, t. 78, p. 76.

Geological formation and locality: Carboniferous, l'Ardoisière, France.

c. Lepidocidaris Meek and Worthen 1873.*

General form spherical. Interambulacra very broad with eight or more columns of plates in each area. Plates imbricate laterally and aborally. Each interambulacral plate has one large central tubercle surrounded by a ring. Spines cylindrical, thin, finely striated and swollen at the base. Ambulacra small, slightly arched, imbricating, the whole plates alternating with wedge-shaped half plates.

1. Lepidocidaris squamosus Meek and Worthen.

1869. *Eocidaris ? squamosa.* Meek and Worthen, Proc. Acad. Nat. Sci. Phil., p. 79.

1873. *Eocidaris ? squamosus.* Meek and Worthen, Geol. Surv. Ill., vol. 5, p. 478, pl. 9, fig. 15.

1874. *Lepidocidaris squamosus.* Lovén, Kongl. Svens. Vetens. Akad. Handl., Bd. 11, no. 7, p. 44.

1889. *Lepidocidaris squamosus.* N. Amer. Geol. Pal., p. 258.

1895. *Lepidocidaris squamosus.* Keyes, Proc. Iowa. Acad. Sci., vol. 2, p. 193.

1896. *Lepidocidaris squamosus.* Jackson, Bull. Geol. Soc. Amer., vol. 7, p. 220, pl. 7, fig. 41.

Interambulacral plates imbricate aborally and toward the central column, except the adambulacral plates which imbri-

* Proc. Acad. Nat. Sci. Phil., 1873, p. 79.

cate outward. Large saucer shaped depression in the center of each plate. Surface beveled to the margins of the plates. Tubercles smooth, prominent, surrounded by small nodes. Primary spines round, slender, closely striated longitudinally.

Ambulacra narrow, imbricating adorally. Plates very unequal in size and form and irregularly arranged. Plates pierced by two pores each.

Geological formation and locality: Lower Burlington Limestone, Burlington, Iowa.

## DOUBTFUL GENERA.

### a. Discocystis Gregory 1897.*

### b. Echinodiscus Worthen and Miller 1883.†

#### 1. Echinodiscus kaskaskiensis Hall.

1858. *Agelacrinus kaskaskiensis.* Hall, Geol. Iowa, vol. 1, pt. 2, p. 696, pl. 25, fig. 18.

1894. *Echinodiscus kaskaskiensis.* Keyes, Mo. Geol. Surv. vol. 4, p. 133, pl. 18, fig. 3.

Geological formation and locality: Kaskaskia Limestone, Kaskaskia, Ill.; Ste. Mary's, Mo.

#### 2. Echinodiscus optatus Worthen and Miller.

1883. *Echinodiscus optatus.* Worthen and Miller, Geol. Surv. Ill., vol. 7, p. 336, pl. 31, fig. 9.

Geological formation and locality: Chester Limestone, Monroe and Pope Cos., Ill.

#### 3. Echinodiscus sampsoni Miller.

1891. *Echinodiscus sampsoni.* Miller, Adv. Sheets, 17th Rep. Geol. Surv. Ind., p. 76, pl. 12, fig. 6.

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* Quart. Journ. Geol. Soc. Lond., vol. 53, p. 112.

† Geol. Surv. Ill., vol. 7, p. 335.

1892. *Echinodiscus sampsoni.* Miller, 17th Rep. Geol. Surv. Ind., p. 686, pl. 12, fig. 16.

1894. *Echinodiscus sampsoni.* Keyes, Mo. Geol. Surv., vol. 4, p. 133.

Geological formation and locality: Keokuk Limestone, Boonville, Mo.

c. Eotiaris Lambert 1900.*

d. Koninckocidaris Dollo and Buisseret 1888.†

e. Leptechinus Tornquist 1897.‡

1. Leptechinus gracilis Tornquist.

1897. *Leptechinus gracilis.* Tornquist, Abhdl. Geol. Karte Elsass-Lothr., bd. 5, heft 6, p. 785, taf. 20, fig. 5.

Geological formation and locality: Carboniferous, Hunsrückenwald, Germany.

f. Myriastiches Sollas 1899.§

1. Myriastiches gigas Sollas.

1899. *Myriastiches gigas.* Sollas, Quart. Journ. Geol. Soc. Lond., vol. 55, pt. 4, p. 700, fig. 5.

Geological formation and locality: Lower Ludlow Limestone, England.

g. Permocidaris Lambert 1900.‖

h. Proterocidaris De Koninck 1881.¶

1. Proterocidaris giganteus De Koninck.

1881. *Proterocidaris giganteus.* De Koninck, Compt. Rend. de l'Assoc. Franç. pour l'Avance. des Sci. 10e Sess., p. 514, pl. 8.

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* Bull. Soc. Yonne, t. 53, 1 er Sem., pt. 2, p. 40.

† Compt. Rend. Acad. Sci. Paris, t. 106, no. 13.

‡ Abhdl. Geol. Karte Elsass-Lothr., bd. 5, heft 6, p. 785.

§ Quart. Journ. Geol. Soc. Lond., vol. 55, pt. 4, p. 700.

‖ Bull. Soc. Yonne, t. 53, 1er sem., pt. 2, p. 39, 47.

¶ Assoc. Franc. pour l'Avance. des Sci. Compt. Rend. de la 10e Sess., Alger 1881, p. 514.

Geological formation and locality: Carboniferous, Loyers, Belgium.

i. Protocidaris Whidborne 1898.*

1. Protocidaris acuaria Whidborne.

1898. *Protocidaris acuaria.* Whidborne, Palaeont. Soc., vol. 52, p. 203, pl. 25, figs. 1–2 a.

1899. *Protocidaris* ——. Sollas, Quart. Journ. Geol. Soc. Lond., vol. 55, pt. 4, p. 709.

Geological formation and locality: Pilton Beds, East of Barnstaple.

j. Protoechinus Austin 1860.†

1. Protoechinus anceps Austin.

1860. *Protoechinus anceps.* Austin, Geologist, vol. 3, p. 446.

1874. *Protoechinus anceps.* Lovén, Kongl. Svens. Vetens. Akad. Handl., bd. 11, no. 7, p. 42.

Geological formation and locality: Carboniferous, Wexford, England.

k. Spatangopsis Torell 1869.‡

1. Spatangopsis costata Torell.

1869. *Spatangopsis costata.* Torell, Acta Univ. Lund., Math. et Natura, 1869, art. 8, p. 11.

Geological formation and locality: Cambrian, Lugnas and Timmerdala, Sweden.

l. Xenocidaris Schultze 1866.§

1. Xenocidaris clavigera Schultze.

1866. *Xenocidaris clavigera.* Schultze, Denkschr. Akad. Wiss. Wien, Math. Naturw. Cl., no. 26, p. 126, tab. 13, figs. 3–3 h.

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* Monog. Palaeont. Soc. London, vol. 52, p. 203.

† Geologist vol. 3, p. 446.

‡ Acta Univ. Lund., Math. et Natura, 1869, art. 8, p. 11.

§ Denkschrift Akad. Wiss. Wien, Math. Naturwiss. Cl., no. 26, p. 126.

1874. *Xenocidaris clavigera.* Lovén, Kongl. Svens. Vetens. Akad. Handl., bd. 11, no. 7, p. 44.

1900. *Xenocidaris clavigera.* Hesse, Neu. Jahrb. Miner. Geol. u. Pal., beil. bd. 13, p. 212.

Geological formation and locality: Devonian, Mühlenberg near Gerolstein.

### 2. Xenocidaris conifera Schlüter.

1881. *Xenocidaris conifera.* Schlüter, Verhdl. Nat. Ver. Preuss. Rheinl. u. Westfal. Bonn, Sitzungsb., bd. 38, p. 212.

Geological formation and locality: Middle Devonian, Hillesheimer-Mulde between Kerpen and Nollenbach.

### 3. Xenocidaris cylindrica Schultze.

1866. *Xenocidaris cylindrica.* Schultze, Denkschr. Akad. Wis. Wien, Math. Naturw. Cl., no. 26, p. 126, taf. 13, figs. 4–4 c.

1874. *Xenocidaris cylindrica.* Lovén, Kongl. Svens. Vetens. Akad. Handl., bd. 11, no. 7, p. 42.

Geological formation and locality: Devonian, Gerolstein.

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* An asterisk prefixed to a title indicates that the author has not seen the article.

† A dagger prefixed to a title indicates that the article is in the library of Dr. Hambach.

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## EXPLANATION OF ILLUSTRATIONS.

### Plates I–VI.

Plate I. — 1, Interambulacra of *Melonites multiporus.* — 2, Interambulacra of *Melonites crassus* (type specimen). — 3, Interambulacra of an *Oligoporus* from the Warsaw Limestone at Boonville, Mo.

Plate II. — 4, Interambulacra of *Melonites multiporus.* — 5, Interambulacra of a small *Oligoporus* from Boonville, Mo.

Plate III. — 6, Interambulacra of *Melonites multiporus*, showing the genital plates. — 7, Interambulacra of *Melonites multiporus.*

Plate IV. — 8 a–e, Interambulacra of *Melonites multiporus.* — 8 f, Teeth of *Melonites multiporus* figured in 8 a–e. — 9 d, Apical system of *Melonites multiporus* figured on Pl. V., figs. 9 a, b.

Plate V. — 9, *Melonites multiporus.* Interambulacra of a large specimen showing the successive enlargement of the individual pieces. — 10, Interambulacra of *Melonites multiporus,* showing the same feature. — 11, Apical system of *Melonites multiporus* (?) (Magnified two diameters). — 12 d, Apical system of *Melonites multiporus* figured on Pl. VI., figs. 12 a–c.

Plate VI. — 10 c, Interambulacrum of *Melonites multiporus* showing the mode of lateral expansion by the deposition of rings of calcareous substance. — 12, Interambulacra of *Melonites multiporus.* — 13, Interambulacra of *Melonites multiporus.*

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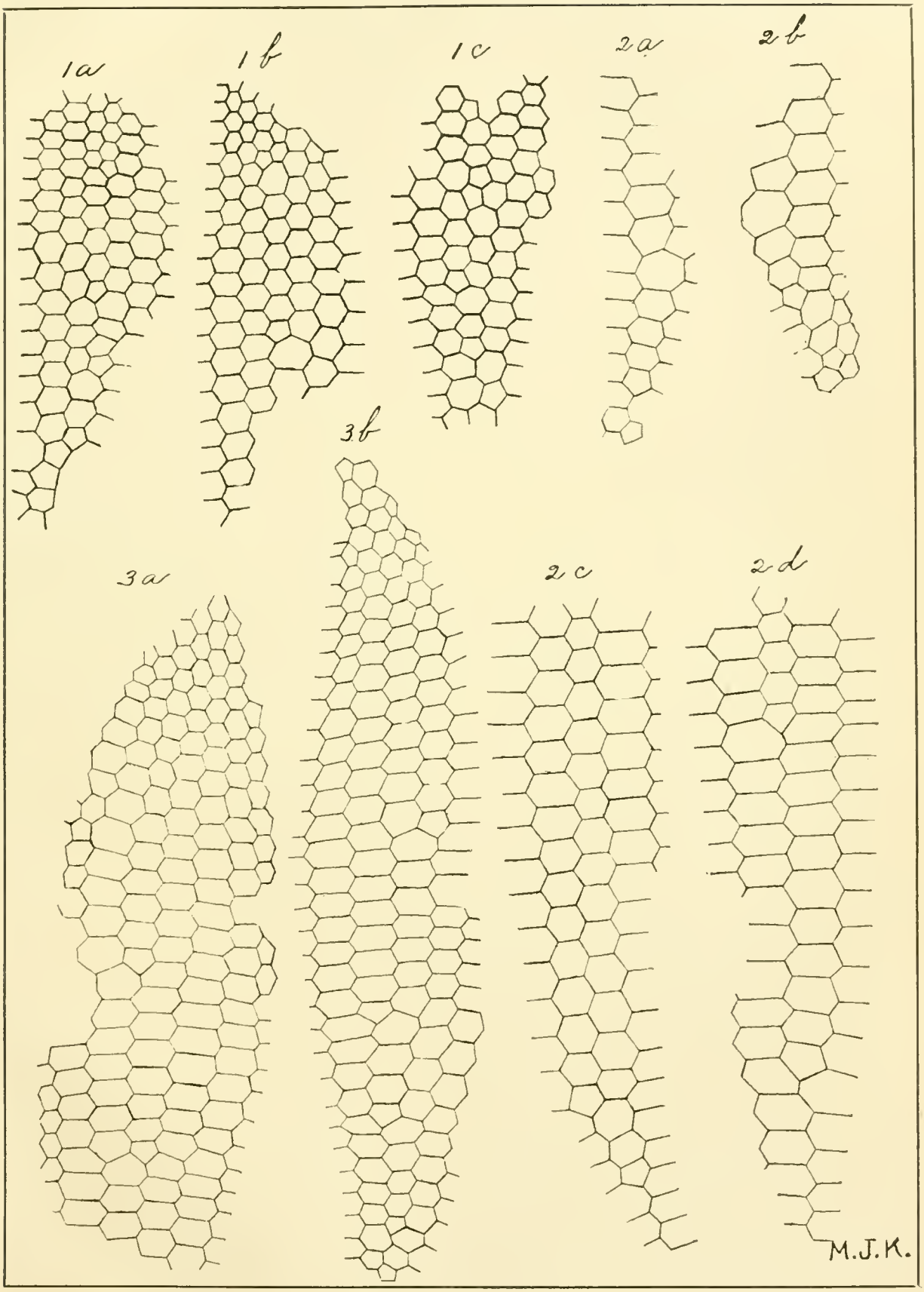
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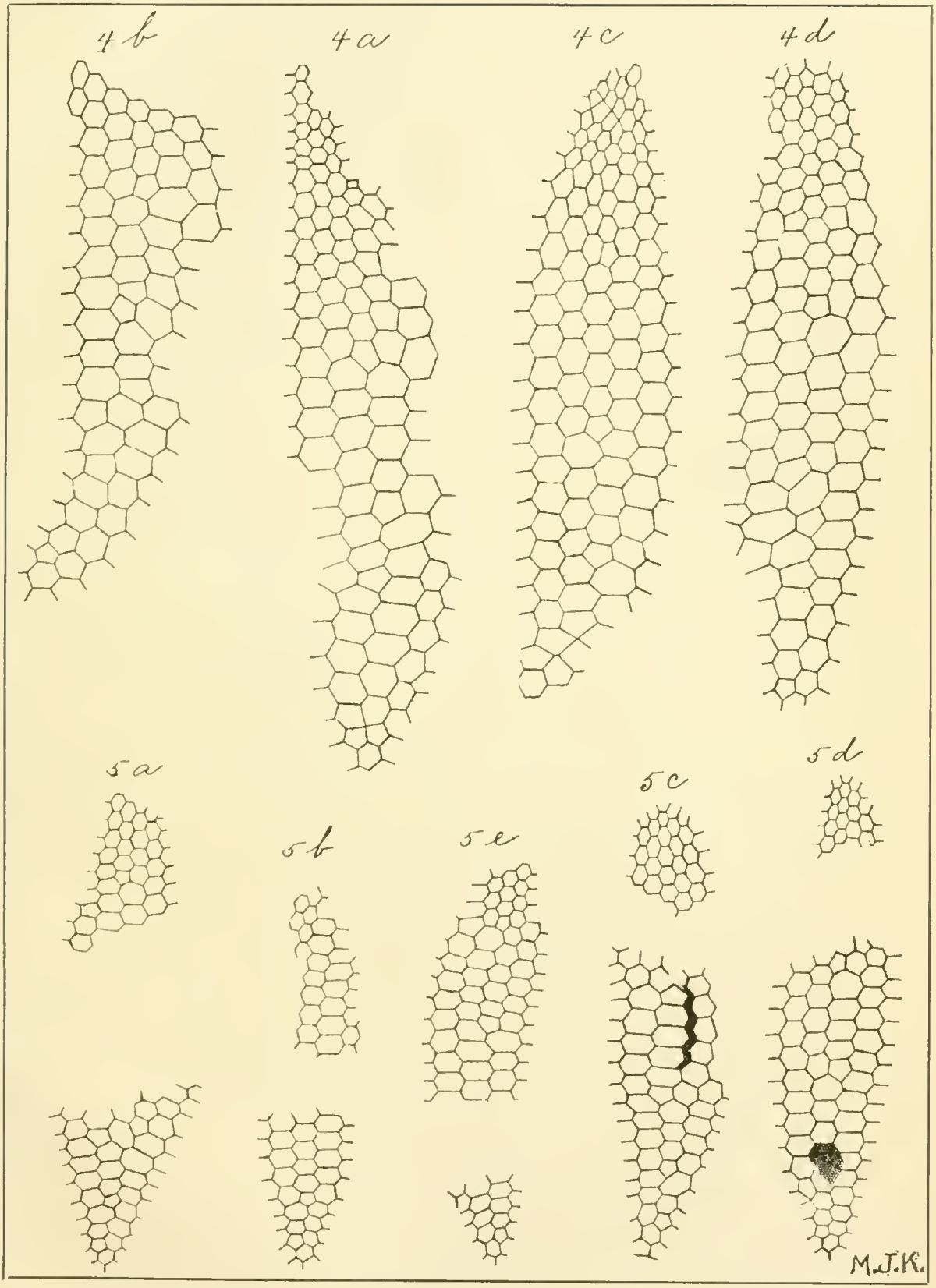
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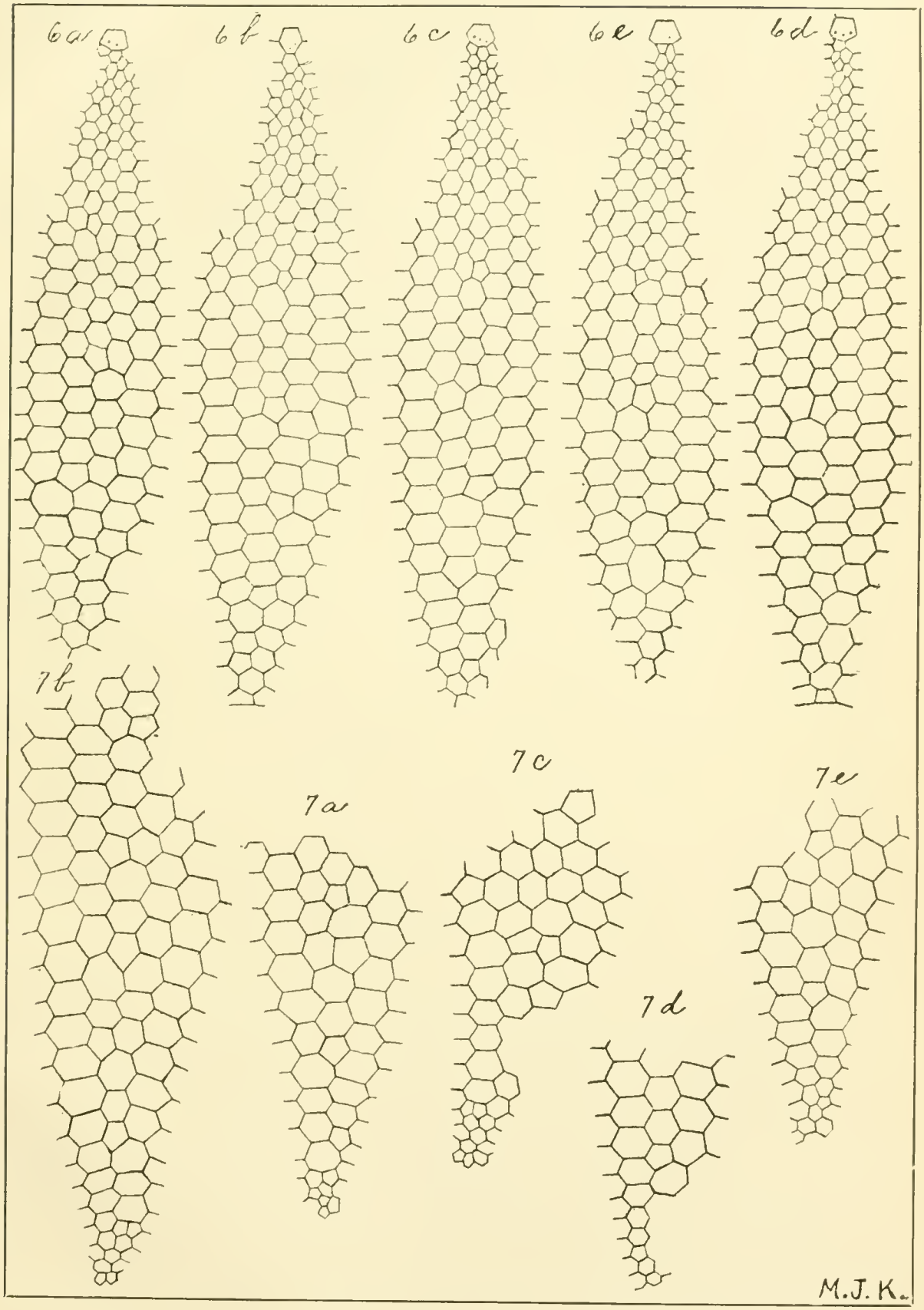
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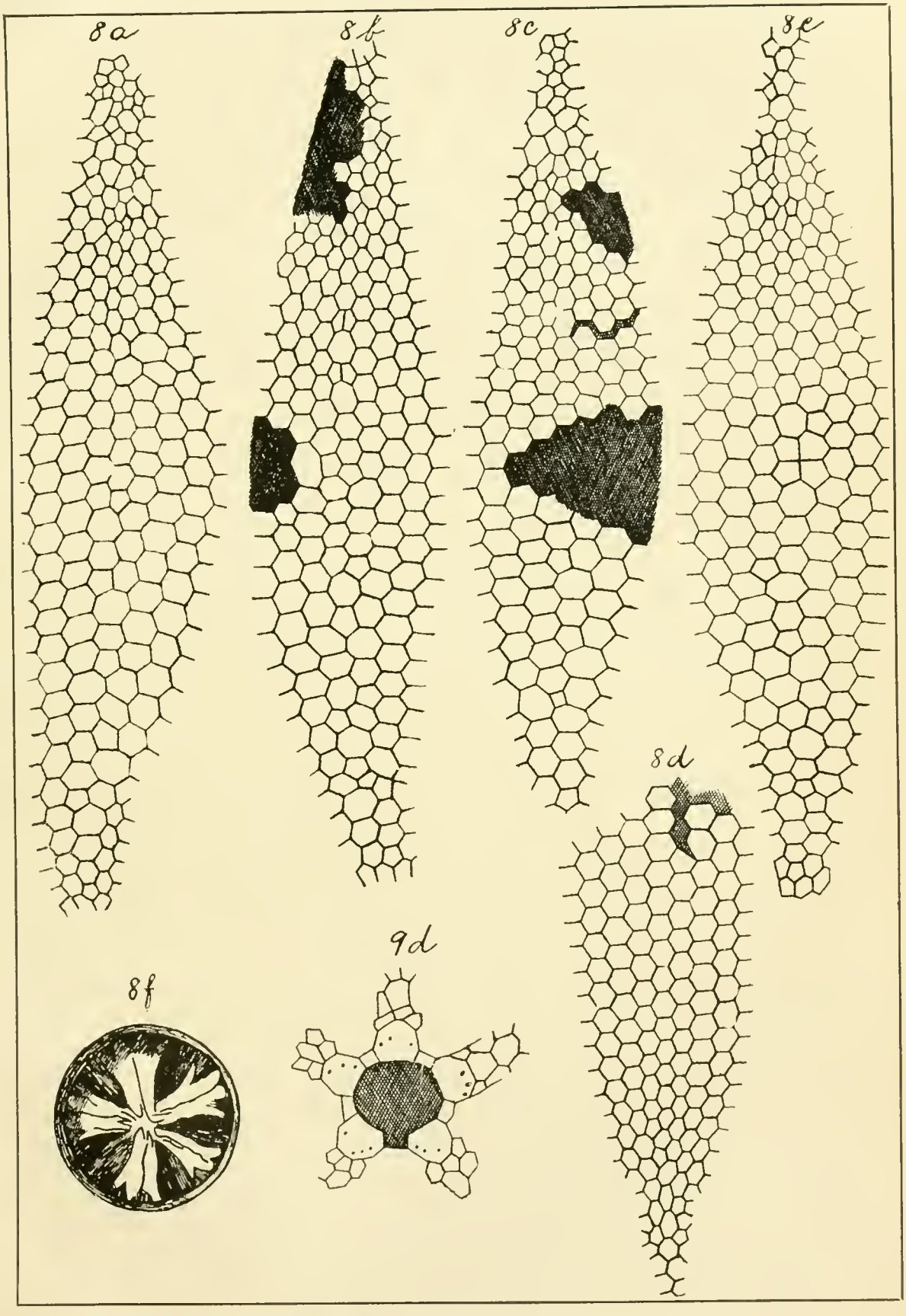
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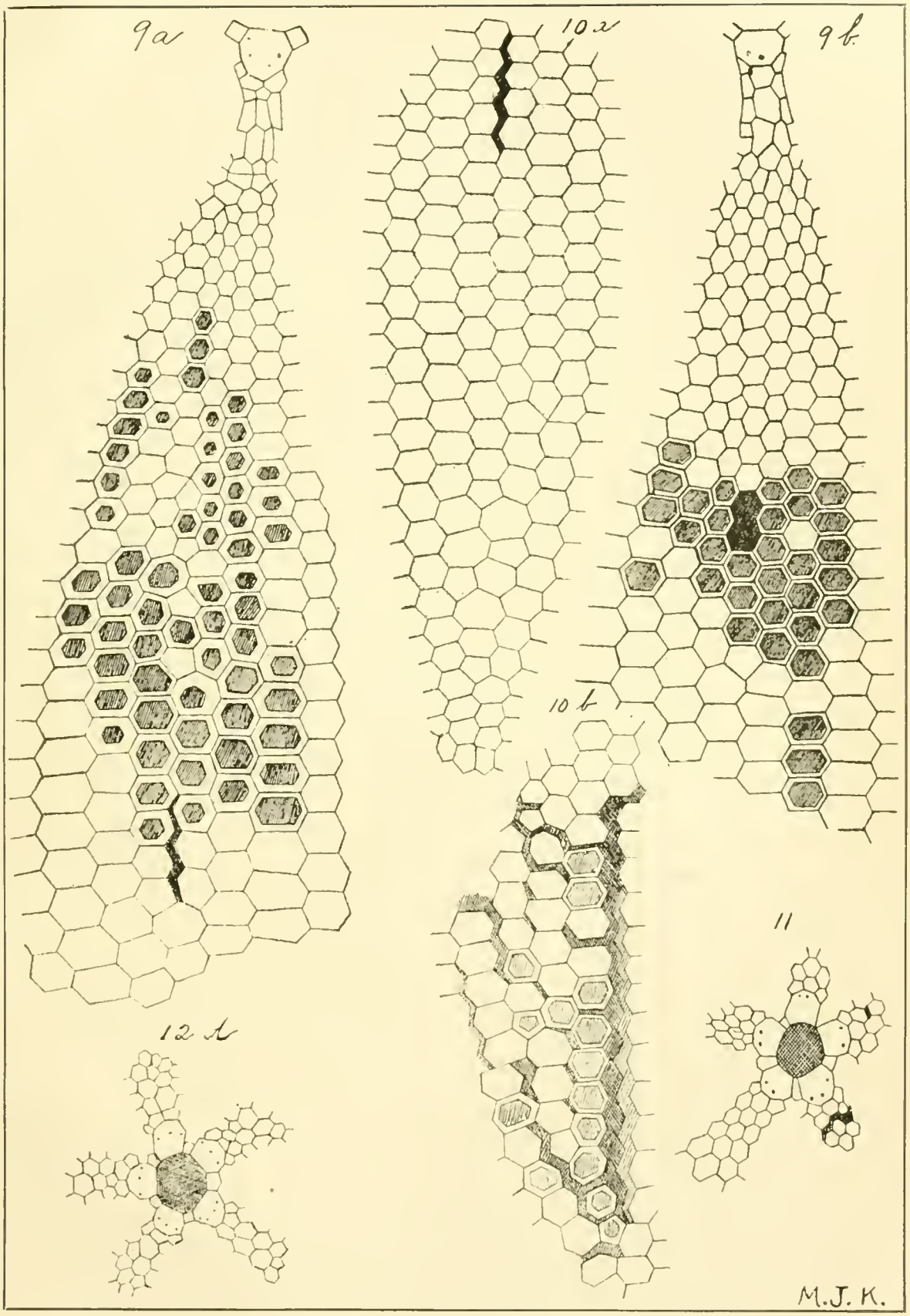
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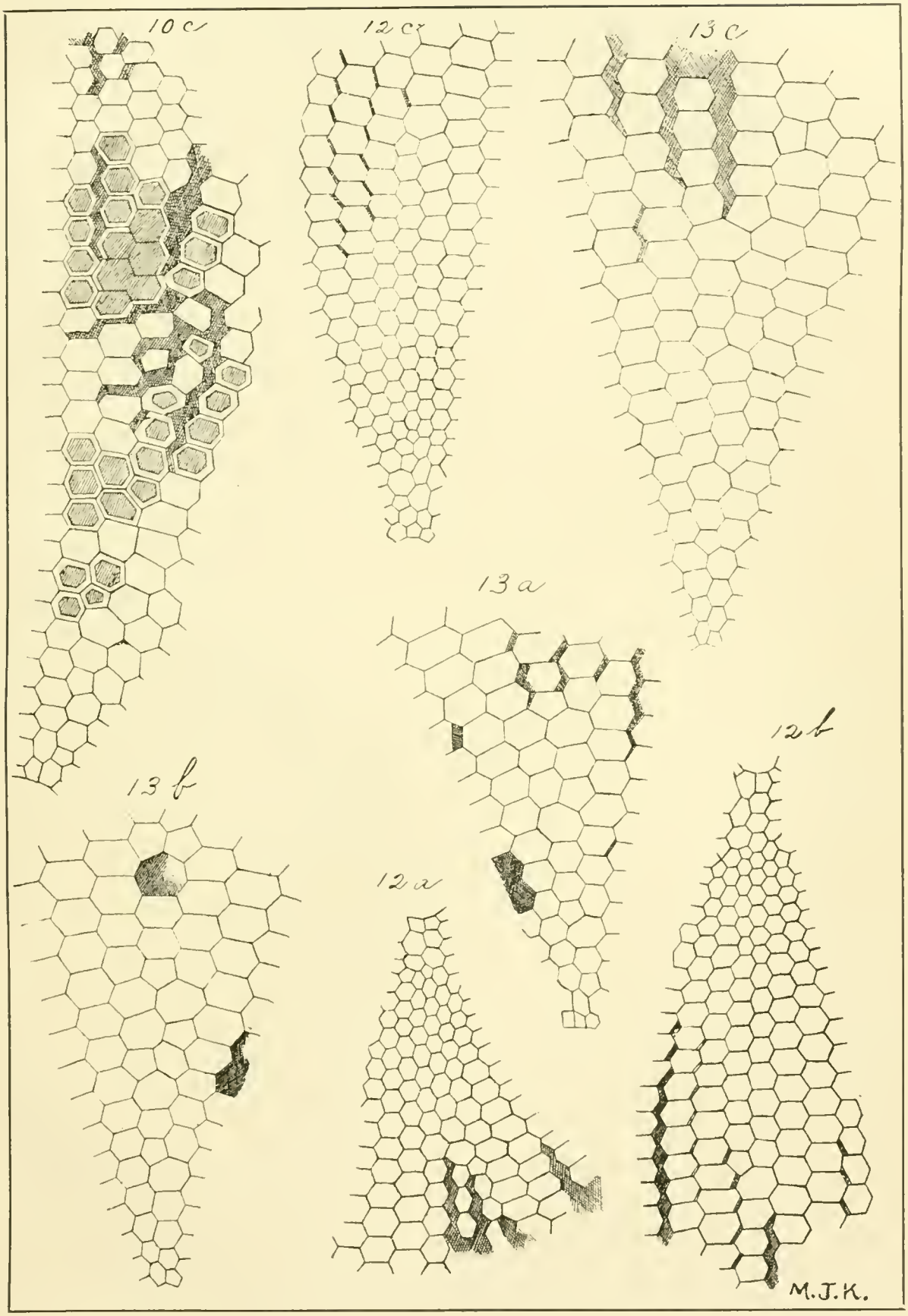
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FRANK COLLINS BAKER.

*Issued May 11, 1904.*

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# THE MOLLUSCAN FAUNA OF THE DELLS OF WISCONSIN.*

Frank Collins Baker.

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## I. Introduction.

The 1903 Field Day of the Chicago Academy of Sciences is one that will long be remembered by those who took advantage of this opportunity to visit one of nature's choicest retreats, at Kilbourn, in the Dells of the Wisconsin River. It was the good fortune of the writer to spend a week in this delightful region, from July 6 to 13, which made possible a very complete natural history survey of the Dells. Acknowledgments are due to Mr. Nat Wetzel and Mr. Frank R. Wheeler, the president and the treasurer of the Wisconsin Dells Co., to the Chicago, Milwaukee and St. Paul Railroad for many courtesies, and to Messrs. F. M. Woodruff and T. J. Staley, Jr., for assistance in collecting.

## II. Topography of the region.

The region of the Dells of the Wisconsin is situated in Juneau, Adams, Sauk and Columbia counties, Wisconsin, 194 miles from Chicago. The overlying rock in this part of the State is Potsdam sandstone of varying hardness. The Wis-

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consin River has cut for itself a devious channel in this rock, from 100 to 150 feet in depth and from 52 feet to half a mile in width. The area studied embraces a tract bordering the river for about four miles in the Lower Dells and about three and a half miles in the Upper Dells.

The locality is a notably picturesque one, characterized by cañons, glens and ravines which have been cut by small streams flowing into the Wisconsin River. These lateral cañons and glens are from 100 to 140 feet in depth and vary from a few rods to over a mile in length. The sides of the cañons are very precipitous and frequently almost meet in some places, forming passages such as "Fat Man's Misery" in Cold Water Cañon. The walls are overgrown with moss, ferns and lichens and present an enticing spot for the botanist.

The reported character of the country, a Potsdam sandstone covered with coniferous trees, had led me to expect a very poor fauna, especially insects and mollusks. I was considerably surprised, therefore, upon studying the region, to find both a varied and abundant fauna, not only of the invertebrates, but of the vertebrates as well. This diversity of life is probably due to the abundance of deciduous trees, the fallen logs and branches of which become soft and afford ample protection for many small animals. In the glens and cañons the greatest variety is found, although the wooded plateaus between the cañons and glens also support a rich fauna, especially of insects and spiders. The whole region is a curious mixture of coniferous and deciduous trees. In some places the two kinds are mixed together, while in others each kind occupies a separate and restricted area. Fungi, lichens and mosses are everywhere abundant and the ground is moist about the decaying tree trunks, affording excellent retreats for the smaller land snails.

We have been led to declare, as a rule, that snails will not flourish in a sandstone region, and particularly in a locality where pine trees are abundant, but the Dells region is an exception to this rule, for snails were found here under logs which lay on beds of pine needles, in the midst of pine woods.

## III. Comparison of the material.

A comparative study of the fauna of the different cañons and glens is of some interest. Several species, as Pyramidula alternata, were abundant everywhere, while others, as Euconulus fulvus and Cochlicopa lubrica, were found only in one cañon or glen. It will be seen by comparing the annexed table that the restricted species are Bifidaria corticaria, Philomycus carolinensis, Euconulus fulvus and Cochlicopa lubrica. Strobilops affinis was the most abundant small mollusk, and was found under almost every stick or log. The large snail, Polygyra multilineata, seemed to be very rare, scarcely a dozen specimens being found during the eight days of collecting.

COMPARATIVE TABLE OF DISTRIBUTION.

| Cold Water Canon. | Artists' Glen. | Witches Gulch. | Cold Spring. | Lower Dells. |
|---|---|---|---|---|
| Polygyra multilineata | Polygyra multilineata | ..... | ..... | ..... |
| P. monodon fraterna | P. monodon fraterna | ..... | ..... | P. monodon fraterna |
| Pyramidula alternata | Pyramidula alternata | Pyramidula alternata | ..... | Pyramidula alternata |
| ..... | ..... | Pyramidula striatella | Pyramidula striatella | ..... |
| Zonitoides arboreus | Zonitoides arboreus | Zonitoides arboreus | ..... | Zonitoides arboreus |
| Zonitoides nitidus | ..... | ..... | ..... | Zonitoides nitidus |
| Strobilops affinis | Strobilops affinis | Strobilops affinis | Strobilops affinis | Strobilops affinis |
| Strobilops virgo | ..... | Strobilops virgo | ..... | ..... |
| ..... | Bifidaria corticaria | ..... | ..... | ..... |
| Euconulus fulvus | ..... | ..... | ..... | ..... |
| Helicodiscus lineatus | ..... | ..... | Helicodiscus lineatus | ..... |
| Vitrea hammonis | ..... | ..... | Vitrea hammonis | ..... |
| Philomycus carolinensis | Philomycus carolinensis | ..... | ..... | ..... |
| Agriolimax campestris | Agriolimax campestris | ..... | ..... | ..... |
| ..... | ..... | ..... | Cochlicopa lubrica | ..... |

## Systematic Catalog of Species.

### Class **PELECYPODA**.

#### Family Unionidae.

The following species were seen from the Lower Dells. The height of the river prevented the collection of the fresh-water clams, which were said to be common at low water.

Lampsilis alata Say.

Lampsilis gracilis Barnes.

Lampsilis ligamentina Lamarck.

### Class **GASTROPODA**.

### Order PULMONATA.

#### Suborder **Basommatophora**.

#### Family Physidae.

Physa gyrina Say.

Several specimens of this species were found in Cold Water Cañon, and in a small pond near the road which enters Witches Gulch a large number were found. The shells are very black.

Limnaea desidiosa Say.

Abundant in small pond near Witches Gulch.

Limnaea humilis Say.

One specimen was found near Cold Spring.

#### Suborder **Stylommatophora**.

#### Family Cochlicopidae.

Cochlicopa lubrica Müller.

A single specimen of this species was found by Mr. Woodruff near Cold Spring.

## Family Pupidae.

Bifidaria corticaria Say.

This species was very abundant in old logs on the sides of Artists' Glen. All of the specimens collected had a single tooth on the parietal wall. They were most abundant under "started" bark, a single piece of bark often concealing a dozen specimens.

Strobilops affinis Pilsbry.

This was the most abundant small snail and was found everywhere.

Strobilops virgo Pilsbry.

Apparently quite rare and seemingly restricted to Cold Water Cañon and Witches Gulch. While trying to identify these small shells the writer hit upon the plan of moistening the base of the shell and holding it near the light, so that the number and position of the small lamellae within the last whorl could be distinctly seen. This has proven quite successful and does away with breaking the shell to see the lamellae.

## Family Endodontidae.

Helicodiscus lineatus Say.

Found only in Cold Water Cañon and at Cold Spring, and not common at either place. The few specimens collected were very large.

Pyramidula alternata Say.

Abundant everywhere. The jelly-like eggs of this species were very common. In many places the young snails, about 3 mm. in diameter, had hatched and were actively crawling about.

Pyramidula striatella Anthony.

Abundant in Cold Water Cañon, Witches Gulch, the Lower Dells and at Cold Spring.

PHILOMYCUS CAROLINENSIS Bosc.

This slug was very abundant in the woods in and bordering Artist's Glen and in the woods bordering Cold Water Cañon. In the latter place it was found feeding on the fungus Pluteus cervinus, in the early morning. Every log which was damp beneath supported one or more of these curious animals. I have stated elsewhere that Philomycus is solitary in habit, and while this may be true in some localities it is not so for the Dells region, for as many as four or five specimens were found under a single log, many times bunched together.

AGRIOLIMAX CAMPESTRIS Binney.

Found abundantly, associated with the last species.

## Family ZONITIDAE.

ZONITOIDES ARBOREUS Say.

Very common in Cold Water Cañon, Witches Gulch, Lower Dells and Artist's Glen, associated with Strobilops affinis and Vitrea hammonis.

ZONITOIDES NITIDUS Müller.

Cold Water Cañon and Lower Dells; not common.

EUCONULUS FULVUS Draparnaud.

Cold Water Cañon, rather common.

VITREA HAMMONIS Ström. (radiatula Alder).

Cold Water Cañon and Cold Spring, not common.

## Family HELICIDAE.

POLYGYRA MULTILINEATA Say.

Artist's Glen and Cold Water Cañon, not common. It is probable that the lack of limestone in this region discourages the larger helices from inhabiting this area in any number.

POLYGYRA MONODON Rackett. Var. fraterna Say.

Artist's Glen, Cold Water Cañon, and Lower Dells.

This is one of the most abundant helices in this region.

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VOL. XIV. No. 3.

# NOTES ON PLANORBIS TRUNCATUS MILES.

FRANK COLLINS BAKER.

*Issued May 11, 1904.*

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# NOTES ON PLANORBIS TRUNCATUS MILES.*

Frank Collins Baker.

On page 291 of the "Mollusca of the Chicago Area" the writer stated his opinion that Planorbis truncatus and Planorbis trivolvis were closely related, the latter being thought to be the ancestor of the former. A detailed study of the two species has brought to light some interesting facts which seem of enough importance for publication.

The principal characteristics of truncatus are its very flat spire, angulated whorls and strong spiral sculpture, the latter being confined to the base and periphery, but not appearing on the upper surface of the whorls. These lines are strongest on the periphery and become fainter as they approach the wide umbilicus. The flat spire is bordered by a strongly raised keel, and the lines of growth are strong, elevated and more or less curved. The color of most specimens examined is light horn, similar to some of the Polygyras.

While examining several thousand Planorbis trivolvis under the microscope, it was discovered that all of the young shells, up to and including the second whorl, were marked with spiral lines in precisely the same manner as truncatus, so that the presence of these lines is not a sufficient character by which to separate the young of the two species, as both have flat spires and spiral lines. There are several characteristics, however, which will separate even the young of these two species. The first is the conspicuous size of the whorls, those of truncatus being about twice as large as those of trivolvis up to the third whorl, when the latter increases in a much larger ratio. Truncatus has 4 whorls when full grown, while trivolvis has $4\frac{1}{2}$ to 5 (although in all the books it is described as with 4 whorls).

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Another distinguishing characteristic is the manner in which the whorls of the young shells form in contact. In truncatus the spire is perfectly flat for all of the whorls and the sutures form strong, elevated ridges from the elevation of the carina of the whorl above the dorsal plane. The nucleus, also, is simply a slightly elevated oval disk, perfectly in accord with the general truncated aspect of the whole spire.

In trivolvis the whorls impinge in such a manner as to form a depressed suture, and each whorl, beginning with the second, is raised a trifle above the last. The nucleus is much smaller than that of truncatus and is depressed a little below the first whorl. The whorls of truncatus are all rather tightly coiled, while those of trivolvis are tightly coiled in the young shell (2–4 whorls) but become loosely coiled in the adult.

It is the opinion of the writer that truncatus is the ancestral form of trivolvis, and not vice versa, as was stated in the "Mollusca of the Chicago Area," the close relationship being shown in the spiral lines and truncated spire of the young of both species. I have not seen the occurrence of fossil specimens of truncatus recorded, but it should certainly be found in the Pleistocene deposits of Michigan.

The geographical distribution of truncatus is somewhat limited judging by the records, which give the following localities: Saginaw Bay, Michigan (Miles); Elk River, Antrim Co., Michigan (Walker); Millers, Indiana (Higley); North Branch Chicago River and George Lake (Jensen); Chicago Drainage Canal, Summit, Illinois (Baker); Port Austin, Mich. (C. A. Davis); Bayport, Mich. (Mrs. A. C. Lane).

The species seems to be extremely rare and but a half dozen specimens have rewarded the efforts of the Chicago Conchologists during the past twenty years. It is one of the handsomest of the Planorbes and it is to be hoped that further search will add new localities and bring a number of specimens to light.

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VOL. XIV. No. 4.

# PRIMITIVE CONDITIONS IN THE SOLAR NEBULA.

FRANCIS E. NIPHER.

*Issued May 18, 1904.*

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# PRIMITIVE CONDITIONS IN THE SOLAR NEBULA.*

FRANCIS E. NIPHER.

In a recent number of these Transactions,† the author has deduced the general equations for the contraction of a gaseous nebula. The nebula was considered as a heat engine. The piston face is any spherical surface, concentric with the gravitating center. The load on the piston is the weight of layers of the gas superposed upon the piston face. As contraction proceeds, this load increases in a perfectly definite way, due to the increasing weight of superposed layers, as their distance from the center decreases. It was shown that in the equation $Pv^n = A$, the values $A$ and $n$ were both constant. The value $n$ was found to be

$$n = \frac{2C_p + 4C}{2C_p + 3C} = \frac{6\kappa - 4}{5\kappa - 3} = 1.101,$$

where $C_p$ is the specific heat at constant pressure; $C$ is the constant for the gas, $\left(\frac{Pv}{T}\right)$ in heat units, and $\kappa$ is the ratio of the specific heats $= 1.41$. In other words the value of $n$ is constant for all gases.

The equations of that paper enable one to draw some very interesting conclusions concerning the nature of the primitive solar nebula.

If the nebulous gas be assumed to extend to an infinite distance, and it be assumed that the condensation has reached such a stage that the mass of the present solar system is internal to Neptune's orbit, we may compute by means of equations (19) and (20) the pressure and density at that radial

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† Trans. Acad. of Sc. of St. Louis, Vol. XIII; No. 5.

distance from the center. The pressure in atmospheres is found to be $1.74 \times 10^{-7}$, and the density in grammes per cc. is found to be $1.40 \times 10^{-12}$. These values remind one of the conditions in a highly exhausted Crookes tube. It is at once evident that we can hardly conceive planetary masses being separated from a nebula having such a high degree of attenuation.

Of course the assumption made implies that the mass external to Neptune's orbit is infinite. The pressure at Saturn's distance from the center would be $2.85 \times 10^{-6}$ atmosphere, and nevertheless more than half of the entire mass of the solar system would lie in the spherical shell between the orbits of Saturn and Neptune.

In order to examine the case of a nebula having a finite mass we may introduce into eq. (10) of the former paper a constant of integration. This constant is so chosen that the pressure becomes zero at any radius $R_0$. Eq. (10) then becomes

$$P = A^{\frac{2}{2-n}} B \left[ \left( \frac{1}{R^2} \right)^{\frac{n}{2-n}} - \left( \frac{1}{R_0^2} \right)^{\frac{n}{2-n}} \right] \qquad (51)$$

$$\text{where } B = \left( \frac{4n - 3n^2}{(2-n)^2 2\pi k} \right)^{\frac{n}{2-n}}.$$

In this equation, $k$ is the gravitation constant $= \frac{1}{1.502 \times 10^7}$. Since $P = A\delta^n$, the density at any distance $R$ will then be

$$\delta = A^{\frac{1}{2-n}} B^{\frac{1}{n}} \frac{1}{R^{\frac{2}{2-n}}} \left[ 1 - \left( \frac{R}{R_0} \right)^{\frac{2n}{2-n}} \right]^{\frac{1}{n}}. \qquad (52)$$

Since $\frac{P}{\delta} = Pv = CT$ it will be observed that pressure, density and temperature all approach zero, as $R$ approaches $R_0$. This of course means that the law of a perfect gas does not hold for the outer layers of the nebula. It also seems to indicate that there is no very serious danger of the heated

gases from the interior escaping from such a nebula, since molecular motion must cease at the outer limit.

The mass internal to any radius $R$ is

$$M = 4\pi \int_0^R R^2 \delta dR .$$

Making $R = xR_0$ where the extreme limits in $x$ are $0$ and $1$, and substituting $\delta$ from the previous equation the value of $M$ is

$$M = 4\pi A^{\frac{1}{2-n}} B^{\frac{1}{n}} R_0^{\frac{4-3n}{2-n}} \int_0^x \frac{1}{x^{\frac{2n-2}{2-n}}} \left(1 - x^{\frac{2n}{2-n}}\right)^{\frac{1}{n}} dx. \qquad (53)$$

The value of $f(x)$ in this equation was platted for values of $x$ between 0.001 (where $f(x) = 4.720$) and unity. The integrals determined by means of the planimeter are given in the following table.

Mr. James of the mathematical department of Washington University afterwards pointed out that the above integral between the limits $0$ and $1$ could be evaluated in terms of the Gamma function. Putting

$x = t^{\frac{2-n}{2n}}$ we have

$$\int f(x)dx = \frac{2-n}{2n} \int_0^{t^{\frac{2-n}{2n}}} t^{\frac{4-3n}{2n}-1} (1-t)^{\frac{1+n}{n}-1} dt$$

| $x$ | $\int_0^x f(x)dx$ |
|---|---|
| 0.1 | 0.2167 |
| 0.2 | 0.3685 |
| 0.3 | 0.5008 |
| 0.4 | 0.6188 |
| 0.5 | 0.7223 |
| 0.6 | 0.8122 |
| 0.7 | 0.8870 |
| 0.8 | 0.9450 |
| 0.9 | 0.9835 |
| 1.0 | 0.9976 |

Since $n = 1.101$, the function is transcendental and its value is finite. Its value is *

* De Haan. Table 1, No. 8.

$$\frac{2-n}{2n}\int_0^1 t^{\frac{4-3n}{2n}-1}(1-t)^{\frac{1+n}{n}-1}dt$$

$$=\frac{2-n}{2n}\frac{\Gamma\left(\frac{4-3n}{2n}\right)\Gamma\left(\frac{1+n}{n}\right)}{\Gamma\left(\frac{6-n}{2n}\right)}. \quad (54)$$

The numerical value between *0* and *1* is by computation from (54) found to be 0.9975.

The close agreement between this value, and that given in the table of integrals obtained by graphical means, makes it seem desirable to say that the graphical values were first determined, and on a large diagram which was very carefully constructed and measured. The value of $n$ as computed from the independently determined constants $C_p$ and $\frac{Pv}{T}$ for oxygen, hydrogen, nitrogen and air, only differs in the fourth significant figure as is shown in the former paper. It therefore seems justifiable to assume that this integral represents a physical constant which may be relied upon with considerable confidence in the fourth decimal place.

The mass of the entire nebula may therefore be represented by the equation

$$M_0 = 0.9975 \times 4\pi A^{\frac{1}{2-n}}\left(\frac{4n-3n^2}{(2-n)^2\,2\pi k}\right)^{\frac{1}{2-n}} R_0^{\frac{4-3n}{2-n}}. \quad (55)$$

The mass internal to any radius $R$ is

$$M = \frac{M_0}{0.9975}\int_0^x f(x)\,dx\,.$$

The mass $M_0$ of our solar system may be taken as $1.99 \times 10^{33}$ grammes. The mass of the planet Neptune is $1.029 \times 10^{29}$ grammes. Let us assume that the solar nebula

has reached such a stage in its condensation, that the mass of Neptune is external to Neptune's present orbit. What will be the condition of the gas at that radius, and what will be the radius $R_0$ of the entire mass $M_0$? At the distance of Neptune's orbit

$$\int_0^x f(x)dx = \left(1 - \frac{1.029}{1.99 \times 10^4}\right) 0.9975 = 0.997449.$$

By interpolation from the table of integrals above given, this value corresponds to the value of $x = 0.999634$. Hence the radius of the nebula is

$$R_0 = \frac{R}{x} = \frac{4.49758 \times 10^{14}}{0.999634} = 4.49923 \times 10^{14}.$$

The nebula therefore extends beyond Neptune's orbit a distance of $1.65 \times 10^{11}$ cm. or about a million miles.

This computation cannot of course pretend to any real precision as applied to our special case, since the mass of Neptune is so small compared with the mass of the entire nebula. It does apply to a case in which $M_0$ is precisely what we have here assumed it to be. So that we may use this method for exploring the outskirts of such a nebula with a view of learning the physical conditions which must hold in a gaseous nebula.

If the values now determined be substituted in (56) the value of $A$ is found to be $2.396 \times 10^{12}$.

The value of $A$ in (51) gives the pressure in C. G. S. units, which, when reduced to atmospheres, is found to be 0.000,000,000,149 or $1.49 \times 10^{-10}$. The same value $A$ in (52) gives for the density at Neptune's place, the value $1.93 \times 10^{-15}$ grammes per cc. These numerical values hold for all gases. The value of $CT$ at this place is therefore $7.82 \times 10^{10}$. The temperature will therefore depend on the nature of the gas. For hydrogen the value of $C = \frac{Pv}{T}$ is $4.13 \times 10^7$. The temperature would in that case be about

1900° C. For air the value of $C$ is $2.88 \times 10^6$ and the temperature would be about 27000° C., if the nebula were of air.

These values show that at this stage of its history, if the solar nebula had been a gas, the mass would practically all follow the law of a perfect gas, since at Neptune's place the temperatures are far above the critical temperatures for ordinary gases.

The results also show that the effect of the outer layers, which are too cool to follow the law of a perfect gas, is insignificant so far as temperature and pressures within the great body of the nebula are concerned.

The pressures due to them are very small, and the work which they are capable of doing on the entire mass during contraction is correspondingly small.

It certainly seems very probable that these equations may now hold for the sun. But it is clear that they could not have applied to the solar nebula while the various planets were separating from the parent mass. The idea that the nebula was then a gaseous nebula is utterly out of the question. The direction towards which we must turn for a solution of this problem is that indicated in the masterly discussion of G. H. Darwin in the Philosophical Transactions of the Royal Society A. 1889.* The hypothesis that the material composing the planets consisted of a swarm of meteoric masses is not only a reasonable one, but it is the only reasonable one that has been suggested in view of the numerical results which appear to follow from these equations for a gaseous nebula.

The collisions within such a swarm of meteorites would result in the breaking up of those having smaller density and greater brittleness more rapidly than those of a metallic character. The sorting of these masses according to size, and the accumulation of the larger masses towards a gravitating center, discussed by Darwin, explains the increase in density towards the center of the earth. The recent remark of Rutherford concerning the distribution of radio-active matter in the earth's crust, calls in question all of the results which have been

* On the Mechanical Conditions of a Swarm of Meteorites, and on Theories of Cosmogony.

reached from a discussion of underground temperatures as related to the age of the earth, and its past history.

It seems certain that the material composing our earth must have been solid when the moon separated from the earth, and that the outer parts of the sun must have been solid when Mercury separated from the parent mass. In its subsequent history, the sun has fused and vaporized. Its condition now is precisely what might be expected from the teachings of the equations of the present paper. The sun is, certainly, mainly gaseous. Its outer visible limit, is the clouds formed of liquid drops, which occupy the external layers where the temperature is comparatively low, and where some of the material is not gaseous.

The temperatures which will be attained in a condensing swarm of meteorites will evidently be subject to considerable variations. If the masses are uniformly distributed in a spherical volume, the acceleration will approach zero at the central parts, and will increase outwardly along a radius. If it happen that a central core of solid matter has been established, then external to this core, the acceleration will be composed of two terms. The value of one term varies inversely as the square of the distance from the core center, and that of the other, due to the effect of the swarm external to the core, increases directly with the radius. It may therefore happen that the acceleration will be a minimum at some surface within the meteoric swarm, and external to the core. If the whole mass is in rotation around an axis, it is evident that such a distribution of matter would result in the formation of an equatorial ring. The masses external to the position of minimum acceleration would gradually gravitate inward towards the position of minimum acceleration, and those within would gradually separate from it.

In determining the resulting or maximum temperature due to the aggregation of such masses into planets, there is much wider limits for conjecture, than in the case of a gaseous nebula. The variation in average density throughout the swarm of meteorites will depend upon the size and density of individual masses. The energy may be so gradually dissi-

pated by impacts and radiations that the mass may never become fused if the total mass of the planet is relatively small. The possibilities in regard to the former temperature of the earth are under consideration, but no final conclusion can as yet be given. It does not at present seem necessary, or even probable, that the material composing our earth was ever in a state of fusion.

In the case of the central mass left after the separation of Mercury, it is of course easy to understand how this enormous mass should finally fuse and vaporize. Its present condition may be compared with what would result if it had condensed to its present volume from a gaseous nebula filling what might be called an equitable part of the vast space whose radius is the distance to the nearest fixed star, which is $3.06 \times 10^{18}$ cm. We may now compare the value of the radius $R$ of any spherical isothermal $T$ with the radius $R_0$ of the zero isothermal forming the outer limit of the nebula.

By (51) and (52)

$$\frac{P}{\delta} =$$

$$A^{\frac{1}{2-n}} \left( \frac{(4-3n)n}{(2-n)^2 2\pi k} \right)^{\frac{n-1}{2-n}} \left( 1 - \left( \frac{R}{R_0} \right)^{\frac{2n}{2-n}} \right)^{\frac{n-1}{n}} \frac{1}{R^{\frac{2(n-1)}{2-n}}}. \quad (56)$$

Combining this equation with (55) by the elimination of $A$ and replacing $R$ by $xR_0$ in the resulting equation, the value of $x$ is

$$x = \left[ \frac{1}{1 + \left( 0.9975 \frac{(4-3n)n}{(2-n)^2} \frac{2CTR_0}{kM_0} \right)^{\frac{n}{n-1}}} \right]^{\frac{2-n}{2n}}. \quad (57)$$

Hence

$$R = \left[ \frac{R_0^{\frac{2n}{2-n}}}{1 + \left( 0.9975 \frac{(4-3n)n}{(2-n)^2} \frac{2CTR_0}{kM_0} \right)^{\frac{n}{n-1}}} \right]^{\frac{2-n}{2n}}. \quad (58)$$

An inspection of this equation shows that for any fixed value of $T$, there will be a definite value of $R_0$ which will make the radius $R$ of the isothermal $T$ a maximum.

The condition for this maximum is

$$\left(\frac{dR}{dR_0}\right)_T = 0.$$

The condition thus determined is

$$R_0 = \left[\frac{2(n-1)}{4-3n}\right]^{\frac{n-1}{n}} \frac{(2-n)^2}{0.9975(4-3n)n} \frac{kM_0}{2CT}. \qquad (59)$$

According to this equation, the higher the temperature of the isothermal the smaller must be the radius of a contracting nebula when the radius of the isothermal has reached its maximum. This shows that the outer isothermals are contracting, while the inner ones are enlarging. The maximum radius $R$ of any isothermal is found by substituting the value $R_0$ of (59) in (58). The maximum $R$ is

$$R = \frac{\left[\frac{2(n-1)}{4-3n}\right]^{\frac{n-1}{n}} \frac{(2-n)^2}{0.9975(4-3n)n} \frac{kM_0}{2CT}}{\left[1+\frac{2(n-1)}{4-3n}\right]^{\frac{2-n}{2n}}}. \qquad (60)$$

In like manner this value $R_0$ in (57) gives for the value of $x$ when $R$ for any isothermal is a maximum

$$\left(\frac{R}{R_0}\right)_{R=max.} = x_m = \left[\frac{4-3n}{2-n}\right]^{\frac{2-n}{2n}}. \qquad (61)$$

In the former paper it was shown that for oxygen, hydrogen, nitrogen, and air, $n = 1.101$. Hence

$$x = 0.901.$$

This shows that in a cosmical gas-kugel of such mixed gases, the particular isothermal which at any time during the contraction of the nebula is at a distance $R = 0.901\ R_0$, will then be at its maximum. Isothermals internal to this will be increasing in radius, while those outside will be contracting. This condition is due to the fact that the outer limit of the nebula has a constant temperature of zero. The isothermals originate at the center and enlarge as the contraction proceeds, while the inward motion due to contraction is greatest at the external surface, and approaches zero at the center. When an isothermal has reached a radius $0.901\ R_0$, it continues to approach the outer limit of the nebula, but on account of contraction, its radius is really diminishing. The temperature of this particular isothermal may be computed from (59).

The isothermal of 7000° C. is now probably at the surface of the sun. If the solar system had been evolved from a gaseous nebula from its early stages, this isothermal would have reached its maximum radius, when the radius of the nebula, $R_0 = 3.09 \times 10^{15}\ cm.$ This is about one thousandth of the distance to *a Centauri*. The radius of the isothermal itself was $0.901\ R_0$.

Equation (57) should apparently enable us to compute what may perhaps be called the height of the solar atmosphere. This is the present distance from the isothermal 7000° to the outer limit of the solar mass where the pressure is zero. Let $C = 2.88 \times 10^6$ which is the constant for air. Let $M_0 = 1.987 \times 10^{33}$, which is the solar mass in grammes. The solar radius will be taken as $R_0 = 6.961 \times 10^{10}\ cm.$ The

$$\text{gravitation constant} = \frac{1}{1.502 \times 10^{10}}.$$ Then is

$$\left[0.9975 \frac{(4-3n)n}{(2-n^2} \frac{2CTR_0}{kM_0}\right]^{\frac{n}{n-1}} = 1.01 \times 10^{-73}.$$

The value of $x$ for this isothermal in such a nebula, having

the solar mass within the solar volume is therefore immeasurably near to unity. The distance from this isothermal to the outer limit of the nebula is a vanishing quantity. The pressure at that isothermal is therefore correspondingly small. This result is, in a general way, in harmony with the evidence given by the spectroscope.

The fineness of the Fraunhofer lines yielded by light from the solar surface, is evidence that the pressure there must be very small.

It is, however, probable that the real temperature of the sun is much lower than it would be if it had developed from the first as a gaseous nebula.

Of course the equations of this discussion assume a quiescent cosmical mass of gas with no external matter. The region around the sun certainly swarms with solid masses which are perhaps in part the remnants of the primitive swarm of meteorites from which the solar system appears to have evolved. These masses when subjected to the fierce radiation from the sun, are perhaps in part vaporized, and their presence must certainly modify the conditions which exist in the region immediately around the sun. The conditions at the solar surface are precisely what might be expected if it is being pelted by meteoric matter.

The temperature of the material composing the various planets of our system has been determined by the heat developed in each by the gravitation of their own masses, after they had separated from the parent mass.

It should not be understood that the equations of this paper are inconsistent with the existence of gaseous nebulae. The reverse is true. It is also probable that more or less of gas may have accompanied the swarm of meteoric masses from which our solar system appears to have been evolved. But it does not seem possible that a planetary system can have developed from a gaseous nebula.

One of the interesting results of this study, is the high temperatures which pervade the enormous volumes filled by the outer layers of the gaseous nebula where the density and

pressure correspond to what we should call a modern vacuum. How would a cosmical mass of gas having a density of $1.93 \times 10^{-15}$ grammes per cc. under pressure of $1.49 \times 10^{-10}$ atmospheres and at a temperature of 27000° C. appear, when viewed as a distant body?

*Issued May 18, 1904.*

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# NOTES ON THE PLEUROTOMIDAE WITH DESCRIPTION OF SOME NEW GENERA AND SPECIES.

THOS. L. CASEY.

*Issued May 19, 1904.*

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# NOTES ON THE PLEUROTOMIDAE WITH DESCRIPTION OF SOME NEW GENERA AND SPECIES.

Thos. L. Casey.

In the "Structural and Systematic Conchology" of Tryon, the family Pleurotomidae is restricted to two genera — *Pleurotoma* and *Halia*. The latter of these being somewhat doubtful in its relationship, we may assume that in the original opinion of Tryon the family Pleurotomidae is made up of the single genus *Pleurotoma*, which he separated into a number of named groups relegated to subgeneric rank. Now while perfectly true that, with our present lights, well-nigh insuperable difficulties beset us in striving to define isolated aggregates of species and classify them in a satisfactory manner, it none the less appears to the writer that the course suggested by Tryon was unphilosophic. Although there seems to be scarcely any limit to the number of genera that might be provisionally admitted — a recent study of rather more than 600 species living and fossil, most of which are in my cabinet, apparently indicating nearly or quite 250 genera, based principally upon embryonal structure, form and position of the anal sinus, form and extent of the canal and general type of sculpture — that is no adequate reason for holding all this diversification of structure and evidence of adaptation to greatly varied environments among at least 3000 species, from the Cretaceous to the present time, to be comprised within a single genus. Later, in the "Manual of Conchology," Tryon considerably modified his original views and admitted several distinct genera which he assigned to sundry groups held to have subfamily rank, but, in this case, it would appear that he rather overestimated the taxonomic importance of certain genera. Granting that the family under consideration comprises only the two genera *Pleurotoma* and *Halia*, as originally

held by Tryon, it would seem more natural to regard these genera only as the representatives of subfamilies — Pleurotominae and Haliinae — which alone would compose the Pleurotomidae. It is possible, however, if not highly probable, that some of the originial subgenera of Tryon, such as *Donovania* (*Lachesis*) and *Mitromorpha*, may really rank as subfamilies or even belong to widely different families.

Probably the course coming nearest to the truth of the matter would be to treat the Pleurotomidae in accordance with the common practice in equally extensive and complex families of arthropods and other classes of animal life, — that is to divide the family or subfamily into tribal sections, each of which is to be separated into more or less definitely limited groups of species which may be known as genera and comprising also, in some special cases, other minor groups or subgenera. The alternative course and the one usually followed in the literature of the Mollusca, would be to divide the families or subfamilies into a comparatively small number of genera, to which a relatively very large number of minor groups are to be attached as subgenera. In the latter case I find it impossible to scientifically define these supergenera, and another objection to this alternative method is that it gives rise to too cumbrous a nomenclature. In the present state of ignorance of true relationships and exact taxonomic weights or values, a name once printed and introduced to nomenclature may as well be regarded as the true surname of the species as of subordinate value, for a subspecies under the latter condition must be represented by four words, and, instead of adhering to the binomial system, we would be shaping a course strongly suggestive of a reversion to the pre-Linnean custom of descriptive names or short descriptive diagnoses and the manifest advantages of the binomial system would be thrown away. It is impossible to devise a system of nomenclature which will serve to indicate at a glance, by the form of the names, exactly the weight or value of taxonomic relationship or isolation and it may as well not be attempted. When we print a tabular statement of species or genera based upon structural characters, we do not by any means desire it

to be understood that the differences between these species or genera are in any way equal, for data enabling us to estimate these interrelationships are in almost all instances lacking, and, in any event, they would be very difficult to decide, for it frequently happens that species which appear to resemble each other very greatly may really be less affiliated by bonds of true affinity than others which differ more conspicuously.

I would prefer therefore to divide a large family or subfamily like the Pleurotomidae, into more or less definitely limited and definable tribal groups, and to regard most of the subdivisions under these tribal headings as true genera until their values can be determined more accurately. This course would seem to be preferable for example in the recently published classification of the Pyramidellidae by Dall and Bartsch (Proc. Biol. Soc. Wash., XVII). The tribes in this case — Pyramidellini, Turbonillini, Odostomiini and Murchisonellini — are probably somewhat less differentiated than those of the Pleurotomidae, but there have been so many generic names published that this course would at least appear to be more convenient than that followed.

The eight tribes of Pleurotomidae indicated by material at present accessible to me may by defined or outlined by the following general characters: —

Animal bearing an operculum; shell usually many-whorled; outer lip generally thin at maturity ..... 2
Animal non-operculate; shell generally smaller and with fewer whorls, frequently characterized by a greater development of plicae about the contour of the aperture and a thickened outer lip at maturity ..... 7
2 — Anal sinus at least distinguishable and usually deep ..... 3
Anal sinus obsolete ..... 6
3 — Sinus more or less distant from the suture ..... 4
Sinus adjacent to the suture ..... 5
4 — Inner lip with little or no deposit of callus posteriorly; shell generally large and moderately thin in substance, the canal usually elongate, the ribbing frequently wanting ..... PLEUROTOMINI
Inner lip with thicker deposit of callus particularly evident posteriorly; shell smaller in size as a rule and thicker in substance, the canal usually much abbreviated; ribs never obsolete ..... CLAVINI
5 — Sinus deep and distinct; shell generally very thin and fragile in substance, inhabiting palaearctic waters exclusively and for the most part living ..... BELINI

Sinus broad, indefinitely limited anteriorly and feeble, sometimes barely traceable; shell usually thick in substance; genera entirely extinct and mostly Eocene .....PSEUDOTOMINI

6 — Shell very small, slender, thick in substance and with short aperture, surface strongly sculptured, ribbed or cancellate.....DONOVANIINI

7 — Anal sinus small but well defined, usually deep and distinct, adjacent to or very near the suture; shell varying greatly in size and thickness of substance, mostly living, the genera and species numerous....DAPHNELLINI

Anal sinus very broad and ill-defined, with its deepest part on the obtuse periphery near the middle of the whorls; shell minute in size and fragile in substance; species few in number; Eocene to present time....TARANINI

Anal sinus obsolete; shell small in size, mitriform, with long narrow aperture, thick in substance; species few in number, recent in development.....MITROMORPHINI

These tribes are not all rigorously isolated or strongly delimited and there are several generic types before me which, from general appearance, may prove to be annectant or doubtfully referable to any of them, but they serve very well in a broad way and there is very seldom any doubt as to the proper reference of a species by its general facies alone.. The genus *Tomella* may perhaps best serve as an illustration of these aberrant forms. This genus, while evidently bearing a phylogenetic relationship with *Perrona*, as shown by the embryo and nepionic whorls, differs so greatly in other characters that it not only cannot be regarded as at present closely allied to *Perrona*, but must be considered one of the most remarkable genera of the entire family. While evidently a member of the tribe Pleurotomini, it departs from its most significant characteristic in possessing a large deposit of callus at the posterior limit of the aperture, though, upon closer observation, it can be perceived that this callus in not quite homologous with the posterior tumid callus of the Clavini and is probably formed in a different way. The chief peculiarity of *Tomella* resides in the form and anterior position of the anal sinus, and in the fact that this sinus is wholly covered and concealed from view by the successive growth of the shell, so that it does not appear upon the spire whorls — a character which isolates it completely in the family.

In making use of the characters before referred to as legitimate criteria for the definition of genera, a large amount of comparative study and latitude of interpretation will be

necessary, and it may be remarked in passing that the general habitus of the shell is frequently a more important criterion than any one of them. For example, it may be correctly assumed that the characters of the embryo are of great weight in an estimation of genera, but I find the variations of this part of the shell must be used with very much more caution than might be supposed necessary, especially in the paucispiral and multispiral conditions, which are of themselves by no means uniformly indicative of generic difference. In some genera such as *Gemmula* Weink. (=*Hemipleurotoma* Coss.) having a rather complex embryo of some five or six whorls, the lower one to three of which are finely costulate, there is a remarkable persistence and stability of form and no perceptible change in type, either in the embryo or general characteristics of the shell, from the earliest Eocene to the present time, and the wholly extinct *Microdrillia* Csy., having a similar embryo, is also constant during the much shorter geological period spanning its history, while in others the normally multispiral embryo may frequently become paucispiral, sometimes as a result of progressive degradation, but in several instances in consequence of varied environment alone.

Of this inconstant type of embryo I have in mind three striking illustrations. The first is afforded by the genus *Eopleurotoma*, of Cossmann, where the embryo is paucispiral and obtuse in normal European species and multispiral and more acute in others. The American representatives such as *sayi*, *haeninghausi*, *nodocarinata* and many more, have a multispiral, closely coiled and rather acute embryo of at least four whorls, although evidently typical *Eopleurotoma* otherwise and so regarded by Cossmann himself; the latter author, however, does not allude to the radical variations of the embryo. The second instance is that of *Pleurofusia* De Greg., the type of which is the American Oligocene *servata* of Conrad, containing many species having the embryo typically multispiral, conical, pointed and closely coiled, but in such forms as *collaris* and *hilgardi* Csy., of the Jacksonian Eocene and *declivis* Con., of the Vicksburg Oligocene, the embryo becomes obtuse and paucispiral, in the last named

species indeed so notably obtuse as to appear swollen owing to the very large nucleus or posterior tip of the embryo — following the terminology of Cossmann. It appears unwarrantable to separate these paucispiral forms from the others, as in general habitus, type of sculpture and all other features they seem to be perfectly congeneric. The third genus, which was founded by De Gregorio upon the American Oligocene *cochlearis* Con. and named *Pleuroliria*, has a multispiral embryo with ribbed lower whorls in its earlier geological stages, but a very small and obtuse paucispiral protoconch, with larger nucleus and almost entirely obsolete riblets, in its later history, the general characters of the shell remaining constant throughout to such an extent that the living form has recently been declared identical with the Oligocene type; — to a superficial view they are indeed completely identical, but the embryos are strikingly different. These examples are mentioned to indicate in some measure the great difficulties and uncertainties that will attend the rigorous definition of genera in the Pleurotomidae — difficulties which are accentuated among the multitude of small non-operculate forms, which, being comparatively modern in development, have the intermediate gradations not yet so thoroughly eliminated as is the case with the almost equally numerous but geologically much older operculate series.

While I feel certain that the number of true genera of Pleurotomidae is much greater than usually admitted, the above discussion may serve to indicate some of the obstacles which will be encountered in the conscientious study of them, obstacles which will not be removed until we understand more thoroughly than now the meaning of all the modifications of structure and sculpture displayed so lavishly among these wonderful and fascinating objects. These modifications of sculpture, form and coloration all mean something, and are caused by varying conditions of adaptation to environment in its broadest sense.

In the subsequent discussion of the tribal groups outlined above, I have included a few genera which seem worthy of

special study, either because of their relative importance or in order to correct certain errors which have appeared in print.

## Pleurotomini.

This tribe is the most extensive of the operculate series and comprises the largest and most conspicuous species of the family. Excepting certain aberrant forms such as *Antiplanes* and *Genota*, the latter of which was considered a Conid by Cossmann, though probably more correctly a Pleurotomid, the genera arrange themselves naturally about the types known as *Pleurotoma*, *Surcula* and *Clavatula*, the first being distinguished by the entire absence of longitudinal ribbing and corresponding prominence of the spiral sculpture, the second having well developed ribs as a rule and inconspicuous spirals, and the third — a special type — distinguished in general by a spiniform modification of the ribbing. These three type forms diverged from a common descent stem in very remote time, the third being the most modern offshoot and peculiarly developed in the middle and upper European Tertiaries and in the living fauna of West Africa. In addition to these, there are certain peculiar fossil types which did not survive the world-wide revolution at the close of the Oligocene, among which may be mentioned *Scobinella* with related genera, distinguished by absence of true ribs, strong spirals frequently interrupted by arrested growth giving a characteristic tessellated sculpture and usually having strongly developed plicae on the columella, a character extremely rare or perhaps entirely wanting among the living forms of the tribe.

### **Pleurotoma** Lamk.

This genus is composed of large and rather slender species, with a high and many whorled spire which is generally somewhat twisted apically, long and more or less contorted though untwisted canal and a deep parallel-sided anal sinus, which is not situated on the peripheral carina, but formed on a flat depressed spiral band just behind the periphery. The sculpture consists of broad close-set and obtuse spiral carinae, the

surface polished and the lines of growth not distinct. The embryo is small, obtuse, smooth and paucispiral, consisting of about a single whorl. *Pleurotoma* is represented by a moderate number of species confined to the Indo-Pacific region, such as *babylonia* Linn., *crispa* Lamk., *grandis* Gray and *garnonsi* of Reeve, and is a recent development, not occurring, as far as known to me, in the fossil state. It probably exists, however, in the unexplored upper Tertiaries of those regions.

**Lophiotoma** n. gen.

Although having the small smooth embryo of a single whorl, polished surface and obsolete lines of growth, characterizing *Pleurotoma*, this genus may be recognized at once by the relatively shorter and stouter form as a rule, less elongate and straighter beak, which is strongly tapering in certain large forms like *unedo*, finer, more acutely elevated and less close-set spiral carinae, with a usually distinct and even, finely lineolate concavity from the peripheral carina to the suture or subsutural collar, the latter being generally present and by the deep anal sinus formed centrally on, and not behind, the peripheral carina, the latter being more strongly elevated and usually subduplex. The genus is exclusively recent, composed of large species inhabiting the Indo-Pacific region and is represented in my cabinet by *tigrina*, *virgo* and *marmorata* Lamk., *unedo* Val., *jickeli* Weink., *leucotropis* A. et R. and the following: —

General form and ornamentation similar to *tigrina* but more slender, the dark brown spots very minute and sparse, but similarly distributed, the duplex peripheral carina more strongly elevated and the anal sinus deeper and narrower. Length of a specimen having 12 body whorls, 59 mm.; width, 13 mm. Cebu, Philippine Islands..... **microsticta** n. sp

**Pleuroliria** De Greg.

This genus, originating in the middle Eocene and coming down to the present time, is the American homologue of *Lophiotoma*, but is composed of much smaller species having a slender form, very characteristic sculpture of two to three strong spiral carinae, the peripheral bearing the small anal

sinus, and a conspicuous system of lines of growth, bi-oblique toward the peripheral carina and composed of excavated lines, which are less evident in the very early forms and most conspicuous in the modern species. The type is *P. cochlearis* Con. of the Vicksburg Oligocene. *Pleuroliria* comprises two groups, which, although strongly resembling each other in general form and type of sculpture, are in reality almost subgeneric in value as shown below: —

Group 1. — *Embryo multispiral and acute.*

Lines of growth less pronounced, uneven and never deeply incised; species small in size and older geologically ..... 2

Lines of growth deeply incised and conspicuous ..... 3

2 — Shell rather slender, each of the spire whorls with a moderate sub-sutured carina, the surface immediately below it being concave and rather rapidly expanding to a stronger peripheral carina perfectly smooth and uniform, and situated at some distance above the middle, the surface thence cyclindric or very feebly descending to the suture below and having two slightly smaller and somewhat approximate carinae at the middle, the lower margin also carinulate. The two carinae below the periphery become more widely separated on the larger whorls, subequally trisecting the space between it and the lower margin, and, on the body whorl, continue thus unaltered to the base of the shell. The concave surface above the periphery has a fine spiral thread above the middle. Embryo moderately stout, conical, closely coiled, rather higher than wide, with five whorls, the four upper smooth, broadly, evenly convex and polished, the lowermost with longitudinal riblets; beak moderately long, the aperture proportioned nearly as in *cochlearis*. Length of a specimen having 5 body whorls, 9 mm.; width, 2.7 mm. Lower Claiborne Eocene of St. Maurice, La ..... **simplex** n. sp.

Shell nearly as in the preceding but with the embryo shorter and stouter, fully as wide as high and not evenly conical but becoming substyliform toward the very acute tip, of five whorls, the lowermost covered with riblets. Spire whorls shorter; carinae below the periphery more equal and close-set, the peripheral carina finely, obtusely crenulate. Length of a specimen of 2 body whorls, 3.4 mm.; width, 1.2 mm. Lower Claiborne Eocene of St. Maurice ..... **crenulosa** n. sp.

3 — Embryo of four whorls, evenly conical, short, fully as wide as high, the upper three whorls smooth polished and broadly convex, the lowermost bearing acute but rather widely spaced longitudinal riblets. Shell rather short and stout, with slender beak, the spire whorls very short, each with two strong thick and equal carinae, one just below the suture, the other near basal third; between the latter and the basal margin there is a fine spiral thread first appearing on about the third whorl; lines of growth only moderately distinct and somewhat irregular. Length of a specimen having 3 body whorls, 4.5 mm.; width 1.7 mm. Jacksonian Eocene of Montgomery, La ..... **jacksonella** n. sp.

Embryo of nearly five whorls, much higher than wide, more rapidly acuminate toward tip, the upper two or three small whorls smooth, the lower two with rather close-set and more or less oblique longitudinal riblets; species much larger, with relatively less abbreviated whorls and very distinct incised lines of growth, the peripheral carina only slightly below the middle of the spire whorls..... 4

4 — The prominent subsutural carina separated from the still stronger peripheral carina by a concave space having several fine spiral threads, this surface being subequal to or only slightly shorter than the interval separating the subsutural carina from the peripheral carina of the whorl above; embryo large and conspicuous, the riblets strong. Length of a specimen having 8 body whorls, 19 mm.; width, 6 mm. Vicksburg Oligocene (upper and lower). (= *supramirifica* and *tizis* De Greg.) **cochlearis** Con.

The strong and rather more acutely elevated subsutural carina separated from the coarser peripheral carina by a relatively much shorter concave space, which is always very much shorter than the interval between the subsutural carina and the peripheral keel of the whorl above; sculpture otherwise nearly similar, the embryo narrower and with more feebly elevated riblets; shell smaller in size and of slightly more slender form. Length of a specimen having 6 body whorls, 8.5 mm.; width, 2.7 mm. Red Bluff Eocene..... **subsimilis** n. sp.

Group II. — *Embryo small, obtuse and paucispiral.*

Embryo of nearly two whorls, very broad and obtuse at tip, the lower part gradually acquiring some feeble and irregular longitudinal riblets; shell moderately stout, attaining rather large size and thicker in substance, the lines of growth being conspicuously excavated; spiral whorls each with a strong subsutural and a still stronger and thicker submedian spiral carina, the concavity between them gradually acquiring one or two fine spiral threads and the space below the submedian a fine raised line which on the larger whorls gradually becomes a carina equal in size to the subsutural. Length of a specimen of about 9 body whorls, 27 mm.; width, 7.5 mm. Lower Miocene of Alum Bluff, Fla. ..... **barretti** Guppy

Similar to the preceding, but much more slender in form and thinner in substance, the embryo still smaller but rather less obtuse, of scarcely more than a single whorl, the riblets not visible in specimens at hand. Length of a specimen of 11 body whorls, 23.5 mm.; width, 6 mm. Caloosahatchie Pliocene of Shell Creek, Fla..... **albida** Perry

I have not seen the types of *barretti* and *albida*, but assume that the West Florida Miocene species, described above, is identical with the former, as it appears to pertain to the same geological horizon, and adopt Dr. Dall's identification for *albida*. The latter author has recently (Trans. Wag. Inst., Vol. 3, p. 28) confused these two species with the widely different *cochlearis* of Conrad.

The European Miocene *Rouaultia* Bell., seems to share some of the characters of both *Pleuroliria* and *Gemmula*, but has the peripheral carina greatly expanded and crenulate, giving it the general appearance of *Cochlespira*, with which it was confounded by Cossmann. It however differs completely in the form and position of the anal sinus, *Rouaultia* having the sinus on the expanded peripheral carina, as in the two genera mentioned, while in *Cochlespira* it is situated on the concave fasciolar surface between the periphery and suture.

**Gemmula** Weink.

According to the definition given by Cossmann (Essais de Pal. Comp., 2 Livr., 1896, p. 62) there would seem to be no reason to doubt that *P. denticula*, the type of *Hemipleurotoma* Coss., belongs to the same group of species as the living *kieneri* Doum., *monilifera* Pease, and several others, in fact the latter is so similar to the American Eocene and Oligocene *amica* and *rotaedens*, that, following the views of some authors, it might be considered a mere variety. Although I have not seen *gemmata*, the type of *Gemmula*, it is assumed to be entirely congeneric with *kieneri*, *fusca*, *gilchristi* and *monilifera*, which are before me, these four species representing the most typical form of *Gemmula* in retaining the denticulations of the peripheral carina throughout the growth of the shell. The living *albina* Lamk. and *deshayesi* Desm. are somewhat aberrant in having the denticulation of the peripheral carina confined to the very young or nepionic whorls and gradually becoming lost on the larger whorls, as in the American fossil *alternata*, of Conrad, and some other species. The genus will prove to be very extensive, retaining all essential characteristics of form and sculpture from the very early Eocene to the present time, and there will probably prove to be at least 30 species in our Eocene strata alone. The species of *Gemmula* vary in size from relatively small to distinctly above the average of the tribe, and resemble *Pleurotoma* in being devoid of true ribbing or visible lines of growth, in general form, and in the development of spiral carinae, but differ in having

the peripheral carina flattened, duplex to complex, and bearing more or less conspicuous nodules, in having the deep parallel-sided anal sinus borne centrally on the peripheral carina, as in *Lophiotoma*, and in having a large closely coiled multispiral conically or ogivally pointed embryo, with two or three smooth apical, and one to three longitudinally ribbed basal, whorls. The canal is moderately long, and straight, or nearly so. The American fossil species known to me may be identified by the following characters: —

Costuliform denticulations of the more strongly elevated peripheral carina, short, varying in length from scarcely a fourth to a sixth or seventh part of the entire length of the whorls..... 2

Costulations longer, the peripheral band much broader and generally less strongly elevated, about a third as wide as the length of the whorls, the costules usually becoming gradually less distinct on the larger whorls..... 15

2 — Denticulations remaining equally well developed and conspicuous throughout the life of the shell or virtually so..... 3

Denticulations only distinct on the young body whorls, becoming gradually more ill defined and obsolete or subobsolete on the larger whorls; species rather larger in size..... 12

3 — Denticulations in the form of small longitudinal costules from one of the two peripheral carinae to the other, crossing the intervening feeble depression with but partial interruption..... 4

Denticulations feeble, in the form of compressed nodes of the individual peripheral carinae and much broader in a spiral direction than long.. 11

4 — Fasciolar surface below the subsutural carina deeply concave, then rapidly expanding to the strongly elevated peripheral carinae..... 5

Fasciolar surface below the subsutural carinule very feebly concave, but obliquely and only moderately rapidly expanding to the less elevated peripheral carinae..... 7

5 — Form stout, the apex of the beak distinctly reflexed; subsutural concavity with only about two fine revolving threads which are situated at the middle of the concavity; embryo rather large and well developed, higher than wide, with two or three very small smooth whorls at the summit, followed by three larger whorls which are conspicuously costulose, the riblets of the lowest whorl coarser and generally more widely spaced than the others. Red Bluff Eocene.....**amica** Csy.

Form slender, the beak not reflexed at apex; concave surface below the subsutural carina with a greater number of fine spiral threads, about three on the largest whorl of *genitiva*, numerous in *rotaedens;* embryo smaller but almost similarly formed and sculptured..... 6

6 — Peripheral double carina at the middle of the whorls, the denticulations rather fine; form very slender, the aperture and canal combined about a third of the total length. Upper Vicksburg Oligocene...**rotaedens** Con.

Peripheral double carina distinctly below the middle of the whorls, broader, the denticulation coarser and more close-set; form not quite so slender though about equal in length to *rotaedens;* aperture and canal combined more than a third of the total length. Length of a specimen having 6 body whorls, 11.5 mm.; width, 3.4 mm. Lower Claiborne Eocene of Lee Co., Texas.....**genitiva** n. sp.

7 — Whorls with two rather widely separated carinae below the suture; embryo relatively small in size, somewhat higher than wide, with about three small smooth apical whorls, gradually increasing as usual, and two whorls covered with coarse and rather widely spaced riblets; peripheral duplex carina not strongly elevated, the space between it and the lower and larger of the subsutural carinae about twice as wide as the peripheral band and having two spiral threads and sometimes three other smaller ones in addition; space below the periphery with several spiral carinules; shell rather large, the beak straight but somewhat feebly, obliquely swollen toward tip; length of the aperture and canal together nearly two-fifths the length of the shell. Length of a specimen having 9 body whorls, 27 mm.; width, 7.3 mm. Lower Claiborne Eocene of Smithsville, Texas.....**margaritosa** n. sp.

Whorls with a single subsutural carina; species very small in size.....8

8 — Embryo large, much higher than wide and elaborately sculptured.....9

Embryo smaller, about as high as wide, with three smooth rapidly increasing apical whorls and two basal covered with the usual riblets.....10

9 — Embryo forming a regular sharply pointed cone, much higher than wide, the upper three or four whorls smooth, the lower two with riblets, those of the basal whorls coarser, those of the one immediately above it very feeble; space between the peripheral carinae and the subsutural usually with a single spiral thread. Length of a specimen having 4 body whorls, 9.5 mm; width, 3.2 mm. Jacksonian Eocene of the Red River Kimbrel bed.....**conjuncta** n. sp.

Embryo forming a regular sharply pointed cone, much higher than wide, the upper three whorls smooth, very small and together higher than wide, the three lower having a beautifully regular system of strong close-set equal ribbing, occupying the entire embryo except the very small smooth 3-coiled tip; feebly concave surface above the periphery generally having several close-set spiral threads. Length of a specimen having 4 body whorls, 8.9 mm.; width, 2.8 mm. Lower Claiborne Eocene of St. Maurice, La., and also of Lee Co., Texas [Aldrich].....**nucleata** n. sp.

Embryo large, much higher than wide, the lower three whorls subcylindrical and covered with fine arcuate and rather widely spaced riblets, the upper smooth part consisting of two or three whorls very rapidly diminishing in size and together much wider than high; moderately concave surface above the duplex peripheral carina usually having two close-set threads. Length of a specimen having 3½ body whorls, 7.7 mm.; width, 2.8 m.m. Upper Claiborne ferruginous sands, Ala. (= *acutirostris* Con.).....**childreni** Lea

10 — Denticulation of the duplex peripheral carina unusually small and widely spaced, the concave surface, between the periphery and subsutural carinule usually with two fine spiral threads; beak nearly straight, very slender, the aperture and canal combined but little less

than half the length of the shell. Length of a specimen having 4 body whorls, 7 mm.; width, 2.7 mm. Lower Claiborne Eocene of St. Maurice, La.....**parvidens** n. sp.

11 — Spire elongate, gradually and evenly acuminate, about twice as long as the aperture and canal combined; beak gradually acuminate and straight from the abrupt contraction below the convexity of the body whorl; embryo of the *Gemmula* type, well developed, of two or three small smooth whorls followed by about three covered with arcuate riblets; spire whorls each with a strong subtumid subsutural collar which is fully as large and prominent as the obtusely crenulate and obscurely double, generally narrow and feebly elevated peripheral carina, the latter distinctly below the middle; space below this carina with a single spiral carinule; space above it to the subsutural collar, broadly, evenly and rather feebly concave, with numerous very fine spiral threads; peripheral crenulations of the body whorl apparently rather less distinct; they become constantly longer in a spiral sense from one whorl to the next below. Length of a specimen having 6 body whorls, 14 mm.; width, 3.9 mm. Lower Claiborne Eocene of Lisbon, Ala.....**lancea** n. sp.

12 — Crenulate periphery at, or only slightly below, the middle.....13

Crenulate periphery at, or extremely near, the lower or anterior margin of the spire whorls.....14

13 — Crenulations of the periphery fine, apparently not more than a seventh or eighth as long as the whorl, becoming obsolete on the seventh or eighth body whorl; subsutural collar apparently present on the crenulate younger whorls; embryo imperfect in the types. Length of a specimen of about 10 body whorls, 48 mm. Claiborne (ferruginous sand).....**alternata** Con.

Crenulations coarse, becoming on the sixth body whorl large, low, tumescent rounded elevations, with no distinct principal carinae, the entire surface having rather close-set and equal fine spiral carinules; on the upper whorl the crenulations are more abruptly formed and are crossed by about three rather coarser lines, but the periphery nowhere has the abruptly elevated form seen in *rotaedens* and allies; the periphery is distinctly below the middle of the whorl and not at the middle as it seems to be in *alternata*, and the crenulations are nearly a fourth as long as the whorl, about 18 in number; upper whorls with a distinct subsutural collar which disappears completely on the larger whorls; body whorl below the posterior end of the aperture having rather coarse lines separated by about three smaller close-set threads. Length of a specimen having 6 body whorls about 19 mm.; width, 5.6 mm. Lower Claiborne Eocene of St. Maurice, La.....**obsolescens** n. sp.

14 — Shell moderately stout, the spire gradually, evenly acuminate and but little longer than the aperture and canal combined; embryo much higher than wide, with numerous riblets as usual; spire whorls evenly sculptured throughout with coarser and single finer intermediate spiral lines, not interrupted in longitudinal succession by the obtusely and gradually elevated periphery which bears obtuse crenulations, the latter disappearing altogether on about the seventh whorl; surface broadly, feebly concave from the subbasal periphery to the suture above, the latter having no trace of subsutural collar even on the nepionic whorls.

Length of a specimen of 8 body whorls, 32 mm.; width, 8.5 mm. Lower Claiborne Eocene, St. Maurice, La. ..... **ludoviciana** Vgn.

15 — Costules of the peripheral raised band carried obliquely across the surface between the latter and the subsutural cariniform collar, generally forming a distinct beading on the latter; spiral lines above the posterior end of the aperture very sparse and indistinctly defined, below the latter on the body whorl having the form of coarse conspicuous and widely spaced lyrae, the concave intervals between the lyrae having many close-set striae. Length of a specimen having 6 body whorls, 16.5 mm.; width, 4.9 mm. Upper Vicksburg Oligocene ..... **tenella** Con.

Costules not extending across the rather more deeply concave surface above the somewhat narrower and more strongly elevated peripheral band, the subsutural carina finer and almost even, not at all beaded, the concave surface with three or four close-set and distinctly defined spiral lines; body whorl below the periphery with coarse and widely spaced lyrae; shell similar in form to *tenella* but a little smaller. Red Bluff Eocene ..... **ancilla** Csy.

Costules abruptly confined to the peripheral band as in *ancilla*, the subsutural collar very large, obtusely elevated and coarsely beaded, separated from the peripheral costulose band by a deep abrupt concavity about equal in width to the raised band and bearing a fine and almost even median thread; space below the band with about two close-set and rather fine spirals which are more or less nodulose; shell differing from the two preceding in its smaller size, shorter and much stouter form and thicker substance, the embryo small and more rapidly pointed. Length of a specimen of 5 body whorls, 9.5 mm.; width, 3.6 mm. Jacksonian Eocene of Moody's Branch, Miss ..... **nodulina** n. sp.

*Lancea* is a rather aberrant species in general features of sculpture but seems to belong to the present genus; it is represented by a single rather water-worn specimen. The characters of *alternata* are taken from a very careful drawing from the original type kindly lent me by Mr. Aldrich; Conrad states that *lesueuri*, of Lea, is identical, but the latter is a widely different species, having the anal sinus on the upper concave surface of the whorls. A number of species, not alluded to above, are known, but not being able to study the types or any accurate drawings, I am unable to include them at present; among these are *Pl. mediavia* and *equiseta*, of Harris, and *moniliata* of Heilprin.

It is desirable before discussing the genera of the *Surcula* type to draw attention to a succession of peculiar Indo-Pacific forms, resembling *Pleurotoma* in the absence of true ribbing and great development of the spiral carinae, but differing in

the very obtuse base of the shell, absence of canal and in the very small anal sinus situated well behind the peripheral carina; one of these genera may be named as follows: —

**Tomopleura** n. gen.

In this genus the form is rather slender and elongate, with acute many-whorled spire and a small smooth and generally paucispiral embryo; the aperture is usually about a third as long as the shell. The whorls have each two larger and more conspicuous smooth spiral carinae, one just below the suture, the other at about the middle and also a few other smaller carinae. A moderately concave fasciolar surface, bearing the small but deep anal sinus, is situated between the two principal carinae. Lines of growth generally coarsely incised and very conspicuous, as in *Pleuroliria*. The species are moderate or small in size and rather numerous, those before me being labeled *P. nivea* Phil., the type of the genus, *pouloensis* Jouss., *makimonos* Jouss. and *violacea* Hinds. Such species as *cincta* Lamk. and *bijubata* Reeve, resemble typical *Tomopleura* in general form and sculpture and particularly in the obtuse base, absence of beak and form and posterior position of the anal sinus, but the absence of distinct lines of growth, generally acute and substyliform apex and some other characters would seem to indicate that they are at least subgenerically different.

Among the generic types which may be considered in many respects intermediate between the more typical Pleurotomids which precede and the allies of *Surcula* to be mentioned below, may be cited *Scobinella* Con. (= *Moniliopsis* Con., and *Zelia* De Greg.), *Eucheilodon* Gabb, *Glyptotoma* n. gen., *Sinistrella* Meyer, *Trypanotoma* Coss., *Clinura* Bell., *Cochlespira* Con. (= *Ancistrosyrinx* and *Candelabrum* Dall), *Cochlespiropsis* n. gen., *Protosurcula* n. gen., *Eosurcula* n. gen., *Cochlespirella* Csy., *Microdrilla* Csy., *Aforia* Dall, *Antiplanes* Dall, *Bathytoma* H. and B., and *Megasurcula* n. gen. These genera are all devoid of true ribbing, as in the preceding typical Pleurotomids, but have the spirals less developed. The great

majority of them have the anal sinus situated on a posterior declivous or concave fasciolar surface as in *Surcula* and related genera, but, in some instances, as the very isolated *Glyptotoma*, the sinus is medial and formed on a prominent periphery. This peculiar group of genera is entirely and long since extinct, except *Cochlespira*, which appears to have a history almost as extended as *Gemmula* from the Eocene to the present time, and *Aforia*, *Antiplanes* and *Megasurcula*, which as far as known are exclusively living. It is the only group containing reversed or sinistral shells, a character which seems to be of generic value, as I have never seen a dextral specimen of *Sinistrella americana* Ald., among a very large number examined, although otherwise *Sinistrella* is rather closely allied to *Trypanotoma*, a very distinct genus founded by Cossmann upon the *Pleurotoma terebriformis* of Meyer. It is also the only group in which the plications of the columella become in any way a conspicuous feature, although this character does occur in some of the Surculid genera in a less developed degree; it is greatly developed in *Eucheilodon*, *Scobinella* and *Glyptotoma*. In *Clinura* and *Cochlespira* the whorls are broadly expanded into a thin spiral plate usually reflexed and crenulate at the edge. In *Aforia circinata* Dall, this expansion is reduced to a small but abruptly formed median ring.

**Eucheilodon** Gabb.

This genus is abundantly distinct from *Scobinella* in having the anal sinus formed upon an elevated and prominent peripheral shoulder well above the middle of the whorls, and not in a concave posterior fasciolar area; it also differs materially in the embryo, which, although of the same general multispiral type, is very much larger, and in the form of the outer lip, which does not have the broadly lobed and advanced form of *Scobinella*, in its very narrow linear aperture with more strongly lyrate outer lip and in possessing a columella fold near the posterior end of the inner lip, which is never present in *Scobinella*. The system of columella folds is more elaborate than in that genus and the spiral lyrae are

usually not nodulated by the lines of interrupted growth, which are more apt to appear only between them, so that the peculiar tessellated sculpture of *Scobinella* is wanting or much less developed. There are apparently three known species which may be identified by the following characters: —

Shoulder angle of the whorls obtusely rounded and situated far above the middle; spiral lyrae coarse and close-set..... 2
Shoulder angle broadly angulate in profile and situated only just visibly above the middle; spiral lyrae finer and unequally spaced..... 3
2 — Shell stouter, the lyrae very coarse and somewhat dissected by the lines of interrupted growth, especially on and above the shoulder, giving a granular effect; shoulder angle more prominent and bicarinate. Jacksonian Eocene.....**crenocarinatum** Heilp.
Shell much smaller and more slender, the spiral lyrae not quite so coarse, flat and very clearly defined throughout, not at all dissected by the lines of growth which are only visible in the depressed intervals; shoulder angle evenly rounded. Lower Claiborne Eocene of Texas (= *laeviplicatum* Gabb).....**reticulatum** Gabb
3 — Surface of the spire whorls evenly declivous from the finely unicarinate periphery posteriorly to the fine subsutural carina, and, anteriorly to the suture, the posterior declivous surface with a fine thread near the peripheral carina and another one-third the distance from this thread to the subsutural carina, the anterior declivous surface with two fine carinae one-fourth and three-fifths the distance from the peripheral carina to the suture; body whorl below the posterior end of the aperture becoming abruptly closely lyrate; columellar folds numerous but very fine and feeble, the posterior isolated fold small though abruptly denticuliform. Length of a specimen having between 2 and 3 body whorls, 10 mm. Lower Claiborne Eocene of Texas...**gabbianum** n. sp.

The type of *gabbianum* is a unique specimen in the cabinet of Mr. T. H. Aldrich. There are apparently two species in the Jacksonian Eocene confused under the name *crenocarinatum*, but I am not prepared to define them at present.

**Glyptotoma** n. gen.

Some peculiar small species generally of robust form, having a narrow tumid columella ridge, which is stongly bi- or triplicate and the anal sinus median in position and formed upon a broad double nodose spiral, require separation as a distinct genus for which I would propose the above name. The general type of tessellated ornamentation is strikingly

similar to that characterizing *Scobinella*, and the aperture, canal and embryo are of corresponding form, but the anal sinus is wholly different in form and position and the outer lip is not advanced and arcuately lobed. They have occurred thus far only in the Lower Claiborne Eocene of Texas, and those before me may be readily recognized as follows: —

Broadly rhomboidal in outline, the spire evenly conical, the aperture and very short canal combined constituting nearly half the entire length; lyrae of the body whorl below the periphery very coarse and widely spaced, alternating with single fine raised lines; columellar folds two or three in number. Length of a specimen of 5 body whorls, 11.5 mm.; width, 4 mm..... **crassiplicata** Gabb

Narrower, the spire subventricose or narrowing more rapidly toward the apex; aperture very much less than half the entire length..... 2

2 — Larger species, with a nodulose subsutural spiral and a similar but broader duplex peripheral spiral, the two separated by a concave surface which is rather longer than the subsutural collar, and having a fine nodulose thread at its middle; another similar fine thread is very close to the lower margin of the large peripheral spiral, and, below this on the body whorl, the lyrae are equal, granose and moderately widely spaced, the lines of growth fine, deep and close-set, appearing between the lyrae but independent of the nodules; columellar folds about three in number. Length of a specimen of 5 body whorls, 9 mm.; width, 2.8 mm..... **conradiana** Ald.

Smaller species, with numerous very close-set spirals of coarse nodules, the subsutural gradually splitting into two finer spirals on the larger whorls, the concave space below the collar short and with fine irregular thread or threads; spirals below the peripheral alternating in size to the aperture, then equal and almost in mutual contact to the base of the shell; nodules in longitudinal lines from one lyra to the next, giving a closely costulate appearance which does not exist in the preceding species; columella with two large rounded and very approximate folds at the middle, the lower more oblique than the upper; embryo of about four whorls, higher than wide; aperture and canal relatively longer than in *conradiana*. Length of a specimen of 3 body whorls, 3.9 mm.; width, 1.75 mm..... **parvula** n. sp.

These species are all well represented in the cabinet of Mr. Aldrich, to whom I am indebted for the material at hand.

### **Trypanotoma** Coss.

A very distinct genus, apparently confined to the middle Eocene faunas of the southern United States and characterized by the comparatively small size and slender form of the

species and by the elongate spire, very short and rather oblique aperture, broad shallow sinus formed upon a double submedian and more or less nodulose peripheral elevation and very short, broadly obtuse paucispiral embryo. The three species represented by material in my cabinet may be distinguished among themselves as follows:—

Nodules of the peripheral carinae smaller, not coalescent longitudinally; aperture one-third as long as the shell or nearly so..... 2

Nodules of the peripheral carinae coarser, each being fused with its opposite, forming large longitudinal nodules; spire relatively more elongate, the aperture about a fourth as long as the shell..... 3

2 — Spiral carinules relatively coarser, generally two in number between the central double peripheral carina and the lower margin; lower of the two subsutural carinae nodulose; lines of growth very coarse, cancellating the body whorl below the convexity. Length of a specimen of 5 body whorls, 7 mm.; width, 2.6 mm. Upper Claiborne ferruginous sand..... **terebriformis** Meyer

Spiral carinules fine; spire whorls shorter and more transverse, the second carinule below the suture simple and not nodulose; but one raised line between the periphery and lower margin and another forming the latter; space between the nodulose peripheral carinae and subsutural carinules much longer, being twice as long as the width of the peripheral band; lines of growth distinct and uneven but feebler than in *terebriformis*. Length of a specimen of about 7 body whorls, 10 mm.; width, 3 mm. Lower Claiborne Eocene of St. Maurice, La.. **obtusa** n. sp.

3 — Form very slender; subsutural carinae simple, very coarse and nearly contiguous; peripheral carinae coarse, separated from the subsutural by a concave space which is subequal in length to the width of the peripheral duplex band and having two fine but strongly elevated and very approximate spiral threads; space below the peripheral nodulose band but little longer than the width of the latter and having one coarse carinule and another forming the lower margin; lines of growth strong and uneven on the body whorl below the convexity. Length of a specimen of 9 body whorls, 10.6 mm.; width, 2.8 mm. Lower Claiborne Eocene of Moseley's Ferry, Burleson Co., Texas..... **longispira** n. sp.

In *terebriformis* the spiral depression below the subsutural carinae is only about as long as the width of the duplex peripheral band, while in *obtusa* it is fully twice as long as the latter, giving these two species a distinctly different facies. *Longispira* is widely different, and, besides the characters noted in the table, has a still shorter, more obtuse and scarcely at all reflexed beak, which is sometimes umbilicate along the callus of the inner lip; it was collected in consid-

erable number by Mr. T. H. Aldrich, to whose generosity I owe the examples before me.

### **Cochlespiropsis** n. gen.

This genus is allied to *Cochlespira* but differs greatly in having the beak obliquely elevated near the tip, the periphery of the whorls simply angulate in profile and not lamellarly expanded, reflexed or crenulate and the sculpture extremely minute and feeble, close-set and even, wholly differing in character from that prevailing in *Cochlespira*. The genus seems to have become extinct by the middle of the Eocene, not occurring above the Lower Claiborne, and, in fact, limited as far as known to that epoch. The two species before me may be distinguished as follows: —

Spire above the periphery of the body whorl evenly and rather rapidly acuminate, shorter than the portion below that periphery; sculpture of the body whorl below the periphery consisting of moderately close-set and distinct spiral threads which are somewhat uneven in size. Length of a specimen of 7 body whorls, 20 mm.; width, 6.5 mm. Lower Claiborne Eocene of Wheelock, Texas.....**engonata** Con.

Spire above the periphery more elongate, nearly equaling in length the portion below, very gradually acuminate and more rapidly and arcuately so toward apex; ornamentation of the body whorl below the periphery consisting of extremely minute, closely crowded and equal spiral threads which are frequently somewhat wavy or subinterrupted by uneven irregularities of growth. Length of a specimen of 8 body whorls, 31 mm.; width, 8.8 mm. Lower Claiborne Eocene of Lisbon, Ala.....**blanda** n. sp.

There is no vestige of a tumid or carinulate collar below the suture in this genus.

### **Cochlespira** Con.

The periphery is lamelliform to a greater or less degree in this genus, the edge always crenulate and bent backward, and there is usually a well-marked and finely beaded collar below the suture which, however, sometimes becomes obsolete on the larger whorls. The posterior broad fasciolar surface has some fine spirals near the periphery but is usually completely devoid of sculpture elsewhere, except the arcuate lines of

growth formed by the large anal sinus. Below the periphery the sculpture consists of coarse and close-set beaded lines, the one marking the posterior limit of the aperture larger and more conspicuous than the others. The beak is slender, without trace of the external oblique ridge of *Cochlespiropsis*, the columella straight or broadly and feebly arcuate and the aperture and canal combined are generally as long as the remainder of the shell or nearly so. The type is *C. cristata* Con., of the Vicksburg Oligocene, and the other species known to me as forming typical members of the genus are *bella* Con. and *columbaria* Ald., of the American Eocene, and *terebralis* Lamk., of the European Eocene. I have not seen the living species, *elegans* and *radiata*, of Dall, upon which he founded *Ancistrosyrinx*, and my previous statement as to the identity of the latter genus with *Cochlespira* rests upon the published opinion of Cossmann. If true, *Cochlespira*, *Pleuroliria*, *Gemmula* and *Orthosurcula* would be the only Eocene genera known to me as surviving to the present time. It is probable that the species described by Harris under the name *Drillia dipta*, will constitute the type of a distinct genus near *Cochlespira*. The various minute species of *Cochlespirella* Csy. (Proc. Acad. Nat. Sci., Phila., 1903, p. 279) are left for future consideration.

**Protosurcula** n. gen.

In this genus and *Eosurcula* there is no trace of ribbing, and the moderately large species composing them may be considered allied more closely to the *Cochlespira* group than any other; the embryo in both is conical or conoidal and multispiral, and, in *Protosurcula* is generally very large and with conspicuous longitudinal riblets on the lower whorls. The collar below the suture is cariniform and the long fasciolar surface between it and the obtuse periphery is broadly concave and with fine spiral lines; below the periphery the spiral lyrae are rather coarse. The columella is straight and generally simple, though sometimes having a strong plica above the middle. The spire tapers evenly to the apex and the beak is slender and frequently very long, the aperture and long straight canal combined being much longer than the

remainder of the shell in *gabbi*, which is assumed as the type. The species before me may be distinguished by the following characters: —

Columella straight and unmodified; embryo very large..... 2
Columella with a stout plica at about the middle of the aperture proper; embryo much smaller, though of the same general type..... 3
2 — Embryo stout; subsutural collar flat, composed of two, and, subsequently, about three, coarser spiral carinules; concavity below the subsutural collar, long, concave; periphery anterior in position, rounded in profile, moderately swollen, with the spiral lines larger. Lower Claiborne of Wheelock, Texas.....**gabbi** Con.
Embryo large but much narrower, the lower whorls similarly, though more coarsely, costulate, the upper smooth whorls forming a much more acutely elevated apex; subsutural surface broadly, feebly swollen and covered with numerous fine but strong carinules merging gradually into the small threads of the subjacent concavity; remaining characters nearly as in *gabbi*, the beak more rapidly tapering, very slender at tip, the aperture and canal together but little longer than the remainder of the shell. Length of a specimen of 5 body whorls, 23.5 mm.; width, 6.8 mm. Lower Claiborne Eocene of Smithville, Texas — Mr. Aldrich.....**tenuirostris** n. sp.
3 — Form nearly as in the two preceding, the embryo very much smaller in size, conical, with the lower whorls ribbed; subsequent whorls each with a strongly and abruptly elevated double carina at basal third, the two carinae becoming more widely separated and with an intermediate thread on the larger whorls; space between the double carina and the subsutural cariniform collar broadly concave and with strong and widely spaced spiral threads; double carina of the first two body whorls crenulate. Lower Claiborne Eocene of Wheelock, Texas — [*Borsonia*].....**plenta** H. & A.

The last of these species may possibly be subgenerically different from the others but certainly cannot be further removed. The species figured by Harris as the young of *plenta* is probably specifically different.

### **Eosurcula** n. gen.

The embryo in *Eosurcula* is much narrower than in *Protosurcula*, strongly elevated and smooth throughout, the subsutural collar smaller and less developed, the fasciolar surface thence obliquely ascending but straight in profile or nearly so to the obtusely angulate periphery, on and below which the spirals become coarser. The aperture and canal are nearly as

in *Protosurcula*, but the peculiar narrow elevated embryo, perfectly smooth throughout and without riblets, higher shoulder angle and oblique fasciolar surface, less developed subsutural collar and some other differential characters, will readily serve to separate the two genera, which are perhaps the most characteristic and abundant forms of the Lower Claiborne Eocene,—and impart a marked difference in habitus. The species are more numerous than those of the preceding genus, those known to me being outlined as follows:—

Peripheral carina crenulate, at least on the small upper body whorls, situated at the middle and subduplex. ..... 2

Peripheral carina devoid of any trace of crenulation at any point..... 5

2 — Larger species, the peripheral carina at or above the middle of the whorls, crenulate on the small or nepionic whorls only..... 3

Small species, the periphery more obtusely angulate, more feebly carinate and distinctly below the middle of the whorls; all the whorls apparently crenulate on the periphery..... 4

3 — Peripheral carina at the middle of the whorls, apparently duplex, coarse but only moderately elavated; between it and the base there is another similar double carina; slightly above it, at the lower part of the oblique fasciolar surface, there is a fine spiral carina; declivous space thence to the fine subsutural collar with two or three very fine spiral threads. Texas, Caldwell Co.....**moorei** Gabb

Peripheral carina well above the middle of the whorls; between it and the base there are two carinae, which are apparently smaller than the peripheral and less elevated. Lignitic Eocene of Wood's Bluff, Ala.....**tuomeyi** Ald.

4 — Moderately stout, the subsutural collar small; surface thence regularly ascending to the crenulate periphery and having two or three coarse but feeble spiral lines; surface below the periphery on the spire whorls with two rather coarse and widely spaced carinules in low relief; below these on the body whorl the surface is closely, evenly lyrate. Upper Claiborne ferruginous sand [*Conus*].....**pulcherrima** Heilp.

5 — Peripheral carina double, its upper carinule smaller and less prominent than the lower, the latter a little below the middle; subsutural carina unusually strong, at some distance below the suture, the surface thence to the upper peripheral carina regularly oblique, with a single carinule at lower two-fifths; on the larger whorls a few other very minute and inconspicuous threads can be observed; surface below the lower peripheral carina, with two carinae, the uppermost interval thus formed much the larger, both with an intermediate central and feeble thread; lyrae on the body whorl moderately coarse, well separated and only occasionally with intermediate threads. Length of a specimen of 6 body whorls, 22 mm.; width, 6 mm. Lower Claiborne Eocene of Lisbon, Ala.....**concinna** n. sp.

Peripheral carina single, narrow but strongly elevated, at the middle; subsutural carina, fine; surface thence to the periphery regularly oblique

and covered with rather close-set, fine but sharply elevated threads, the one nearest the peripheral carina much the largest; surface below the peripheral carina cylindric, with a similar carina a little below its middle and another near the lower edge; space between the peripheral carina and the one next below with a finer carina a little below its middle. Length of a fragment consisting of the embryo and 4 spire whorls, 5.6 mm.; width, 3 mm. Lower Claiborne Eocene of St. Maurice, La.....**helicoidea** n. sp.

Mr. Aldrich mentions no crenulation on the periphery of the nepionic whorls of *tuomeyi*, but these are said to exist by Prof. Harris.

### **Bathytoma** Harr. et Burr.

*Dolichotoma* Bell. (nom. praeocc.).

According to Cossmann, this genus exists fossilized in all the Tertiary strata and is also found living, but I am inclined to believe that that author has confused a number of generic or subgeneric types and that the really typical *Bathytoma* occurs only in the upper European Tertiaries, where it is represented by *Murex cataphractus* Broc. The geologically much older American species, from the upper Eocene of Red Bluff and the Vicksburg Oligocene, described by Conrad under the name *Pleurotoma congesta*, is a much smaller species and differs in some respects, perhaps subgenerically, but may be considered a *Bathytoma* for the present. The peripheral ridge is much better marked than in *Megasurcula* and is frequently costulose and the obtuse oblique columellar ridge, very feeble in *Megasurcula* is conspicuous in at least the American *Bathytoma congesta*. This ridge is not homologous with the columellar plicae of some other genera, which are doubtless to be closely associated in any natural arrangement, such as *Scobinella*, and, occurring much lower down on the columella, is probably different in origin and significance.

### **Megasurcula** n. gen.

The embryo in this genus is apparently paucispiral, but conoidal, the canal obsolete, the base of the shell broadly obtuse, the pillar with an oblique ridge externally; sinus large and

broadly rounded, very near the suture, the fasciolar surface below the suture broad and feebly concave, the periphery obtuse and not very prominent, and the suture simple, without subjacent elevated collar. The surface is rendered somewhat rough by relatively fine, close-set and irregular spiral lines, and there is no longitudinal sculpture except lines of growth. The species are large and ponderous, and include *Surcula carpenteriana* and *tryoni* of Gabb, from the coast of California. *Megasurcula* is a widely isolated and strongly characterized genus, belonging exclusively to the living fauna of the Pacific coast of North America as far as known at present. It is, at the same time, a rather direct descendant of the extinct *Bathytoma*, but the species are of far larger size, *carpenteriana* being probably the largest or most ponderous Pleurotomid known. The embryo, which is conoidal and multispiral in *Bathytoma*, has gradually lost some of its whorls, as shown in *Megasurcula*, which of itself would not be a generic character, but there is in *Bathytoma* a broad constriction of the body whorl below the convexity, forming a short stout beak, which is wholly unobservable in *Megasurcula*, and the aperture is much more capacious in the latter, with the anal sinus much larger and different in form and position.

**Asthenotoma** Harr. et Burr.

*Oligotoma* Bell. (nom. praeocc.).

This genus, entirely represented by extinct species of slender form and elevated, evenly and gradually acuminate spire, conspicuous development of the spiral lyrae and short aperture, should evidently be considered with the preceding genera and especially with *Trypanotoma* and allies, but it is somewhat of an annectant form, as the American species at least have true ribbing on the nepionic whorls which becomes completely lost on the larger volutions of the shell. It is therefore one of those puzzling exceptions which render an arrangement of the genera in a dichotomous table so difficult and unsatisfactory. The embryo in the type, *Pl. basteroti* Desm., of the European Miocene, is said by Cossmann

to be paucispiral, but the drawing shows a multispiral protoconch; this is, however, a matter of minor importance. The anal sinus is broad, sometimes very feeble and always median in position on the spire whorls though not identified with any particular one or more of the subequal and rather coarse flat spirals. The beak has no external oblique tumidity. There can be but little doubt, in view of geographical variations and wide distribution of this genus, that *Endiatoma*, of Cossmann, should be regarded as a synonym or as constituting a slightly differentiated section of *Asthenotoma*. The American species known to me may be recognized as follows, the characters of *texana* and *shaleri* being taken from accurate drawings and descriptions. They are all peculiar to the Lower Claiborne Eocene: —

Concavity below the subsutural carina large, extending very nearly to the middle of the whorl, the surface thence to the lower margin having three to four equal and widely spaced spiral lines; spire almost twice as long as the aperture and canal combined. Length of a specimen of 9 body whorls, 18 mm. Texas ..... **texana** Gabb

Concavity below the subsutural carina very short ..... 2

2 — The concavity much longer than the intervals separating the four or five spiral lyrae below it; spire rather rapidly acuminate, apparently not more than one-half longer than the aperture and canal together; form unusually stout; columella straight. Type defective but probably representing a specimen of about 8 body whorls, having a length of 14 mm. Louisiana ..... **shaleri** Vgn.

The concavity not longer than the intervals separating the large lyrae below the middle of the whorls ..... 3

3 — Form somewhat as in the preceding species, the spire rapidly tapering and not more than one-half longer than the aperture and canal combined, the inner outline of the columella broadly, evenly arcuate; spire whorls with a strong flattened subsutural lyra, bordered beneath by a feeble concavity not longer than a seventh or eighth of the total length of the whorl, succeeded by two smaller and more approximate carinules and these by four strong lyrae occupying the entire space thence to the lower margin; on the larger whorls there is a single small raised line alternating with the last-named lyrae. The obtuse ribs of the nepionic whorls are few in number and become completely obsolete on the fourth or fifth whorl. Length of a specimen of 7 body whorls, 12 mm.; width, 3.4 mm. Texas (6 miles south of Wheelock) — Mr. T. H. Aldrich ..... **eximia** n. sp.

Form very much elongated, the spire apparently more than twice as long as the aperture and canal combined, gradually, evenly acuminate; columella somewhat obliquely tumid; spire whorls each with a very coarse

subsutural lyra, two others similar to the subsutural and moderately approximate at the middle and another similar lyra between the lowermost of the median and the lyra forming the lower margin; spiral space below the subsutural lyra exactly equal to the space between the lowermost of the median lyrae and the one next below the latter. Length of a specimen of about 9 body whorls, 15.5 mm.; width, 3.9 mm. Lisbon bed, Alabama — Mr. Aldrich.....**strigosa** n. sp.

*Strigosa* is represented before me by a single specimen in rather imperfect condition, but it is a very distinct species readily recognizable by the characters of the table. The spire whorls are more inflated in *eximia* than in either *strigosa* or *texana*, being arcuate in profile; the sides in those species are nearly straight.

**Hemisurcula** n. gen.

In this genus the shell is fusiform, with the embryo conoidal, multispiral and closely coiled, the nepionic spire whorls alone costate and having also an elevated collar below the suture. The more recent whorls become devoid of lyrae or costae, though having throughout densely close-set and subequal microscopic striae, except the body whorl abruptly below the posterior end of the aperture, which is obliquely and rather coarsely lyrate. The canal is moderate, straight, and, together with the aperture, forms about half the length of the shell. The sinus is broadly rounded and median in position on the spire whorls, the columella simple. The type of this genus is *Pl. silicata*, of Aldrich, a very remarkable and isolated species occurring in the Lignitic Eocene of the Gregg's Landing beds of Alabama. The beaded subsutural collar, subjacent depression and swollen and finely ribbed lower parts of the two whorls immediately below the embryo are lost completely on the larger whorls, though the subsutural collar can be feebly traced as a slightly tumid line gradually descending further below the suture with the growth of the shell. Besides *silicata*, the genus will include the much stouter *Pl. roscoei* Harris, from the same horizon.

**Orthosurcula** n. gen.

Before proceeding to define some of the more typical allies of *Surcula*, it will be of advantage to refer to a generic type as named above, combining some of the features of the preceding group and the true Surculids. The species are large, moderately stout, completely devoid of ribbing and have the beak elongate, tapering, relatively slender and straight. The spirals are close-set, moderate or small in size, sometimes granulose, and the whorls are more or less broadly inflated below and feebly concave posteriorly. The outer lip projects in the middle as a broad rounded lobe beyond the juxta-sutural part, with the sinus large and posterior, as in *Surcula*, and the embryo is paucispiral. The types are the upper Eocene *Pl. longiforma* Ald., of Red Bluff, Miss., and the European Eocene *Surcula transversaria* Lamk. These species have much finer sculpture than the living *Surcula australis* Lamk., which is also an *Orthosurcula*.

**Surcula** H. et A. Adams.

*Turricula* Schum. (nom. praeocc.).

This genus is composed of a moderate number of more or less large species, stout in form, with the beak somewhat elongate and the columella distinctly twisted, the beak generally having a distinct oblique external ridge which is wholly wanting in *Orthosurcula*. The surface has numerous short oblique costae, confined throughout to the peripheral ridge, and, in a few species such as *tornata* only visible on the nepionic whorls, becoming lost on the larger whorls — like the peripheral denticulation of some forms of *Gemmula*. The embryo is small and paucispiral. The median parts of the outer lip project beyond the juxta-sutural part in a broad rounded lobe and the sinus is large, rounded and posterior, in these respects resembling *Bathytoma* and *Megasurcula*. The type is *S. javana* Linn. (=*nodifera* Lamk.), from the coast of China, and the genus will include as well *tuberculata* Gray, *tornata*

Dillw. (=*javana* Kiener non Linn.) and *fulminata* Kiener, from the Indo-Pacific fauna, and the South African *Clavatula gravis* of Hinds. *Surcula*, as far as known to me, is a modern development and most of the very numerous old Tertiary forms will constitute other genera.

### **Pleurofusia** De Greg.

This name was given by De Gregorio to a species which he described and figured under the name *longirostropsis*, stating that it may be a variety of *servata* Con., and indicating the latter species as one of the generic types. Nothing very similar is known to me from the Upper Claiborne ferruginous sand, but there is a specimen in the cabinet of Mr. Aldrich, from the Lower Claiborne, which greatly resembles the figure referred to. At any rate, it seems evident that *Pleurofusia*, as represented by *servata* and the specimen alluded to, must be recognized as valid. The species are moderate to rather small in size and of somewhat slender form, with rather slender, somewhat elongate beak and strong, longitudinally and transversely rounded, almost entire costae, generally some seven or eight in number. The embryo is conoidal and multispiral to obtuse and paucispiral in form, but never has any conspicuous longitudinal riblets. The fasciolar surface is usually well defined, in great part obliterating the ribs below the suture, but in some cases is less evident, the ribs being strong thoughout the length of the whorl. The species chiefly characterize the upper Eocene and Vicksburg Oligocene of the Southern States, but would seem to have originated in such forms as *langdoni* Ald., of the lower Eocene, which has more numerous ribs, and extend upward at least to the lower Miocene of West Florida, where the genus is represented by a species resembling *servata*. The other species known to me are *declivis* Con. and *oblivia*, *vicksburgensis*, *evanescens*, *collaris* and *hilgardi* Csy., with several others still undescribed. Such species as *servatoidea* Ald., will form an allied genus somewhat resembling *Pleurofusia* in the ribbing but differing in the position of the anal sinus and character of the sculpture.

**Tropisurcula** n. gen.

The shell in this genus is small in size, of slender form, with moderately elongate and slender beak and narrow, closely coiled, multispiral embryo, which is higher than wide, and perfectly smooth and polished throughout. The ribs are about equal in number to those of *Pleurofusia* but culminate in transverse prominences at the summit of an angulate median periphery, and sometimes become gradually feebler on the larger whorls. The spiral lines are subequal among themselves, relatively rather coarse but low, and very close-set throughout. The species known to me are two in number as distinguished by the following characters: —

Ribs nine to ten in number, rounded and distinct throughout the length of the whorls, though much more prominent on the peripheral ridge and tending to become extinct on the broad fasciolar surface of the larger whorls; spiral lines coarse but not much elevated, even above, coarser and usually separated by a fine line below, the periphery; apex of the embryo obtuse. Length of a specimen of 5 body whorls, 10 mm.; width, 2.9 mm. Red Bluff Eocene to the Vicksburg Oligocene.....**caseyi** Ald.

Ribs seven or eight in number, more broadly rounded, very prominent on the angulate periphery, becoming rapidly obsolete below, and usually wholly effaced on the fasciolar surface above, the periphery, especially on the larger whorls; spirals rather wide but feebly elevated, close-set and subequal throughout, but still feebler on the fasciolar surface; embryo acute at tip, of five smooth and highly polished whorls, narrowing more rapidly above the two basal whorls, the apical very small. Length of a specimen of 4 body whorls, 7.5 mm.; width, 2.5 mm. Lower Claiborne Eocene of St. Maurice, La.....**crenula** n. sp.

The embryo in *caseyi* is much more evenly and feebly tapering from base to apex than in *crenula*. The former species was described by Mr. Aldrich under the generic name *Drillia*.

**Surculoma** n. gen.

The type of this genus was regarded by Cossmann as a member of his genus *Amblyacrum*, and, while the small pauci-spiral embryo is very nearly the same in general form, all the other characters differ to so great a degree that it is not easy

to comprehend the motives for this association. In *Surculoma* the beak is rather slender and somewhat abruptly formed below the convexity of the body whorl, the ribs large and few in number, the spire whorls always more or less angulate in profile at the periphery and the sculpture invariably consists of minute and very close-set spiral lines. In *Amblyacrum*, however, the beak is thick and gradually formed, the ribs numerous and close-set, the spire whorls almost evenly arcuate in profile and the spiral sculpture coarse and not close-set. The general facies of the shell in the two genera is wholly different. There are four species of *Surculoma* known to me at present, described under the names *tabulata* Con. (=*coelata* Lea)—assumed as the generic type—from the Upper Claiborne sand and *penrosei* and *dumblei*, of Harris, and *stantoni* Vaughan, from the Lower Claiborne of Texas and Louisiana. *Penrosei* Harr., which was published by its author as a variety of *huppertzi*, is in no way closely related to that species, having a radically different embryo as well as a different position of the anal sinus. *Dumblei* is more slender and has a relatively higher spire and shorter aperture than the others, but does not differ otherwise. *Subaequalis*, of Conrad, may possibly be an aberrant species of this genus, although the periphery is decidedly more obtuse; it seems to have the same peculiar minute close-set spiral lines, which, in all the species, alternate with larger lines toward base; it is very stout in form, with short obtuse rounded ribs, the aperture and short slender canal together being fully as long as the remainder of the shell if not longer. The embryo is wanting in the type and apparently only known specimen, which is from the Upper Claiborne sand. A very large and conspicuous umbilicus occurs in *tabulata* as an abnormal character.

### **Microsurcula** n. gen.

This genus is composed of a considerable number of species, all of which are very small, with the body whorls seldom exceeding four in number at maturity. The embryo is relatively large and complex, conical, multispiral, closely coiled and with about five whorls, the lower one to three of which are

covered with fine acute longitudinal riblets. The periphery is more or less obtusely swollen, the ribs small and numerous and reduced in size and reversed in curvature on the broad fasciolar surface, generally attaining the suture or small subsutural collar above. The canal is rather tapering in form, straight, moderate in length, and, together with the aperture, about half as long as the shell. Of the two following species the first is to be regarded as the type: —

Shell very small, with two or three body whorls, moderately stout, the embryo of five whorls which gradually and evenly increase in size, the apical whorl or nucleus very minute, acutely rounded and relatively higher in form, the second to fifth broadly convex and closely covered with an elaborate system of fine riblets, becoming more widely spaced on the fifth and gradually merging without break into the ribs of the subsequent whorls; these ribs are some twelve in number, elevated, rounded, extending throughout the convexity of the body whorl below and to the very fine subsutural collar above, becoming reduced and arcuately reversed in curvature across the fasciolar surface; spiral lines moderately coarse, even and flat, rather widely spaced and without intermediate lines, becoming close-set near the base and slightly smaller and more close-set on the fasciolar surface. Length of a specimen of 2 body whorls, 4.8 mm.; width, 1.5 mm. Lower Claiborne Eocene of St. Maurice, La..... **nucleola** n. sp.

Shell slightly larger and rather more slender, with more elevated and less obtusely rounded periphery, the aperture and canal combined noticeably shorter than the remainder; embryo relatively larger, higher than wide, of about five whorls, the four uppermost smooth, forming a large even cone, the two lower whorls of which are relatively more inflated toward base, the fourth acquiring coarse feeble riblets which grow stronger on the fifth, where they are broadly arcuate and widely spaced; the fifth whorl is large, and more evenly convex and gradually acquires spiral sculpture but no defined peripheral swelling; subsequent whorls with about eighteen small but distinct ribs, gradually becoming obsolete at the lower margin, attenuated and arcuate in reverse on the fasciolar surface but not quite attaining the rather distinct cariniform subsutural collar; on the second body whorl the ribs form acute nodules on the peripheral ridge but do not extend materially below the latter, and, while still distinct on the fasciolar surface, come still further from attaining the subsutural collar; spiral lyrae on and below the periphery moderately coarse, even, well spaced and without intermediate threads, becoming close-set on the beak; on the fasciolar surface they are finer and close-set. Length of a specimen of 2 body whorls, 6.4 mm.; width, 2.0 mm. Lower Claiborne Eocene (from a well seven miles south of Jewett, Texas) — Mr. T. H. Aldrich..... **bellula** n. sp.

This genus will also include *P. georgei* Harr., from the Lignitic Eocene of Wood's Bluff, Ala., and an undescribed

species, figured by Prof. Harris on the same plate as the young of *P. servatoidea* Ald., with which it evidently has no relationship. This latter species seems in fact to be exceedingly close to *georgei*, and appears to be from the same horizon. *Microsurcula* will include, in addition, the Upper Claiborne *Fusus vetustus*, of Lea, and two species from the Vicksburg Oligocene, one of which I recently described under the name *P. intacta*.

**Lyrosurcula** n. gen.

The species of this genus bear some resemblance to those of *Pleurofusia*, but the spire whorls and ribbing are more cylindrical and the spiral lyrae are different in character, being equal and equally spaced among themselves below the fasciolar surface and not enlarged on the ribs to any very noticeable degree. They differ also in the embryo, which, although conical and multispiral, has the lower whorl or two covered with longitudinal riblets, these being absent in *Pleurofusia*. The three species at present before me may be recognized by the following characters: —

Embryo acutely conical, higher than wide, of 6 whorls, the apical or nucleus more swollen and slightly eccentric, the first three smooth, the lower three covered with very regular riblets which at first are very fine, close-set and feeble, becoming gradually coarser and more widely spaced, the sixth whorl gradually acquiring the spiral lyrae, these appearing distinctly between the riblets; fasciolar surface beginning abruptly at the end of the sixth whorl; next two whorls — the first two body whorls — having strongly rounded outline, about eleven feebly elevated and transversely rounded subcylindric ribs, three strong but narrow, well separated spiral lines in rather more than basal half and a declivous, broadly concave fasciolar surface, with distinct arcuate lines of growth and two fine spiral threads and not entirely crossed by the rapidly obsolete ribs; subsutural collar very small and feebly carinulate; canal short, slender and twisted. Length of a specimen having a complete embryo and 2 body whorls, 4.3 mm.; width, 1.6 mm. Lower Claiborne Eocene of St. Maurice, La..... **elegans** n. sp.

Embryo less acute at tip, a little higher than wide, of four whorls, the upper three smooth, the fourth alone with a few widely separated, obliquely arcuate and rather feeble riblets, body whorls nearly as in the preceding, with ten broadly rounded ribs distinct in the inflated subcylindric lower half of the whorls and scarcely intruding at all upon the steeply descending and broadly concave fasciolar surface; the sculpture

throughout is very nearly as in *elegans* but with larger and stronger ribs. Length of the embryo and first three spire whorls, 2.7 mm.; width, 1.5 mm. Lower Claiborne Eocene of St. Maurice, La.....**acuta** n. sp.

Embryo larger and much stouter than in *acuta*, fully as wide as high, acutely pointed, the nucleal tip being small and rather elevated, the whorls four in number, closely coiled, feebly convex, all highly polished and devoid of sculpture, the lowermost only acquiring a few riblets in its last quadrant, which riblets merge gradually into the ten or eleven ribs of the body whorls; lyrae and fasciolar surface nearly as in the two preceding species. Length of a specimen consisting of the embryo and one complete body whorl, 1.9 mm.; width, 1.0 mm. Lower Claiborne Eocene of St. Maurice, La.....**obsoleta** n. sp.

The species described by Harris under the names *vaughani* and *sylvaerupis* also belong to this genus, but, besides differing from those of the table to some extent in the form of the embryo, have the ribs less numerous and relatively larger; the Upper Claiborne *baumonti* may likewise be included as a slightly aberrant or degenerate member. A considerable number of specimens of *elegans* were obtained, but none with more than two body whorls, and it is probable that it may really be a small species when mature; in this case it would contrast greatly with *vaughani* and *sylvaerupis*, which are moderately large species with a many-whorled spire.

### **Leptosurcula** n. gen.

In this genus the form is very slender, fusiform, the canal very long, the aperture and canal together being about half as long as the entire shell. The embryo is relatively very large, higher than wide, conical and composed of five or six polished whorls, the lower whorls gradually acquiring close-set longitudinal riblets, and then, equally gradually, the spiral lyrae. The type is the very isolated *P. beadata* * Harris, of the Texas

* The name "*beadata*" is of an etymology difficult to ascertain. If it is derived from the English word *bead*, referring to the beaded subsutural collar, it is indeed a "barbarism," or, at any rate, a procedure in the formation of specific names which is generally condemned. It is, however, perhaps not so much worse than *mortoniopsis* and *texanopsis* — Latin and Greek hybrids which have been used by two of our authors,— or such words as *texacona*, *texagyra*, *texacola* and *texalta*, which have been employed by Prof. Harris.

Eocene, a slender and much elongated species, with a long slender and gradually tapering beak. The series of small rounded close-set nodules, forming the subsutural collar, are completely independent of the relatively large and oblique costae, which are less than half as numerous. The strong even spiral lyrae are also a peculiar feature.

Among other described genera of the tribe Pleurotomini, special mention should be made of *Eopleurotoma* Coss., very rich in species in the European Eocene and in the American Lower and Upper Claiborne, where it is represented by such species as *nupera* Con. (=*rugosa* Lea and *protapa* De Greg.), *gemmata* Con. (=*tupis* De Greg.), *haeninghausi* Lea, *sayi* Lea (=*monilifera* Lea), *desnoyersi* Lea (=*lintea* Con. and *properugosa* De Greg.) and *nodocarinata* Gabb. In Europe *Borsonia* and *Epalxis* are well known fossil genera, but *Cordiera* would seem to belong rather to the Pseudotomini, as far as disclosed by published descriptions and figures, and is apparently not closely allied to *Borsonia*. The American *Borsonia plenta* belongs to *Protosurcula*, as stated before, and is not related to the true *Borsonia*, which is exclusively European.

There are some other distinct genera among our fossil species which are not further dwelt upon at present, principally because of lack of material. Among these types of more or less isolated genera may be mentioned *Drillia prosseri* Harr. and *Pleurotoma plutonica* Csy., which are congeneric, and the following apparently unique types: *carlottae*, *cainei* and *texanopsis*, of Harris, *exiloides* Ald., *nasuta* Whitf. and *lesueuri* Lea.

## Clavini.

This tribe is less extensive than the Pleurotomini, but is nevertheless composed of numerous generic groups, which are less isolated among themselves than those of the foregoing tribe, a condition due in a great measure to the fact — as before stated of the non-operculate series, — that the Clavini are largely modern in development and include comparatively few extinct types. Many Eocene fossils assigned to that most

astonishing complex known as *Drillia*, do not belong even to the present tribe and are true Pleurotomids. The genus *Drillia* is in reality very limited, and, as far as known to me, includes only its West African type species described by Gray under the name *umbilicata*. The Clavini may be considered to possess three principal types of structure or general facies represented by *Clavus*, *Crassispira* and *Drillia*, but the definition of genera in these sections will prove to be an uncertain and rather unsatisfactory matter. The genus *Cymatosyrinx* Dall, is a rather isolated fossil type, and is truly represented only by *lunata* Lea, and a few other species of our upper Tertiaries, having a peculiarly short, broad and obtuse paucispiral embryo and an external oblique rostral ridge. Many of the species placed with the type, even by its author, do not belong there. Cossmann assumes the name *Cymatosyrinx* for the old and very extensive genus *Clavus*, on the ground of preoccupation, because of the older name *Clava* Gm., but this is evidently inadmissible, *Clavus* being abundantly distinct from *Clava*, and if such generic words as these were not held to be distinct, very great confusion in zoological nomenclature would result. The species figured by Tryon in his "Structural and Systematic Conchology" as a typical *Drillia*, the *gibbosa* of Kiener, does not even belong to that section of the tribe, but should form the type of a genus closely allied to the true *Crassispira* as represented by the West Indian *bottae* Val. and the West African *callosa* Val. and *carbonaria* Rve. Although the shells in this tribe are generally thick and heavy, it is remarkable that some of the largest and heaviest of them, such as the three species of *Crassispira* just mentioned, are seldom or never found perfect when mature, but are invariably largely and roughly decollated. The following genus seems worthy of definition at the present time, as it is quite isolated and one of the oldest known types of the Clavini.

**Eodrillia** n. gen.

The typical forms of this genus are characterized by a smooth, or at most finely and spirally striate surface, well developed, more or less rounded ribs, which do not cross the

concave fasciolar surface below the usually well-developed subsutural collar and frequently tending to disappear on the larger whorls, a very short aperture, short, angulate base with nearly obsolete canal, open anal sinus of the usual form in *Clavus* and a conical pointed smooth multispiral and closely coiled embryo. Among the typical species may be mentioned *depygis* Con. (=*laevis* Con. and *pinaculina* and *solitariuscula* De Greg.), with its varieties *lonsdali* Lea and *surculopsis* and *fita* De Greg., of the Upper Claiborne ferruginous sand and *texana* Con. (=*texacona* Harr.), of the Lower Claiborne of Texas. It is possible that such forms as *tantula* Con., of the Vicksburg Oligocene, may also be included, although in that species there is no well-defined subsutural collar and the ribs attain the suture above. *Eboroides*, of Conrad, is more nearly a *Clavus* and cannot be included.

### Belini.

The species of this small tribe are exclusively inhabitants of European arctic and subarctic waters, as far as definitely known to me at present. They are moderate or small in size and of thin fragile substance, frequently having a whitish coating which is difficult to remove in many cases, and, in others, such as *Typhlomangilia* and *Bela pyramidalis* Ström., bears the characteristic sculpture of the shell. The embryo varies in a most remarkable manner and serves to indicate, with other accompanying characters, some six or seven genera among the present representatives of *Bela*. Cossmann has referred several fossil forms to the genus *Bela* in its broad sense, but there is some doubt if any of them belong to the present tribe. The Australian Eocene "plesiotype" *Bela pulchra* Tate, certainly resembles some forms allied to *Clathurella* more than it does the Belini, especially in the conformation of the posterior parts of the aperture, but the large obtuse embryo would isolate it there, though scarcely more so than the American Eocene *Eoclathurella* to be described below. In any event *Bela pulchra* will form the type of a very distinct genus, probably assignable to the non-operculate series.

## Pseudotomini.

This tribe, composed exclusively of extinct old Tertiary types, is confessedly somewhat artificial in scope. There is a certain general Fusoid habitus common to all, the shell being usually stout in form, with short or obsolete beak and the outer lip is broadly, feebly sinuate posteriorly to the suture, but without a clearly limited notch. *Pseudotoma* was placed among the Conidae by Cossmann and *Cordiera* in the Pleurotomidae. *Fusitoma sipho* Ald., was described by its author as *Fusus siphus* and *Varicobela smithi* Ald., was originally described under the name *Strombus smithi*, while other species, brought together to form the present tribe, were originally assigned to *Fusus*, *Mitra* and *Borsonia*, showing the doubt and uncertainty involving the relationships of the species. My conception of *Cordiera* is derived from the study of a small species from the "Calcaire grossière," labeled *Pl. nodularis* Desh., and, if it is a typical representative of that genus as maintained by Cossmann, there can be no doubt whatever of its very pronounced affinity with our *Mitra biconica*, of Whitfield, and *Borsonia ludoviciana* Vgn., which species may be considered as representing *Cordiera* for the present. As to the relationship between *Cordiera* and *Borsonia*, I am forced to assume that there is very little real affinity, but only a superficially apparent affiliation due to the plication of the columella, a character which is frequently sporadic and of little or no phylogenetic significance in the Pleurotomidae. Although the embryo of our Eocene *Pleurotoma heilprini* Ald., differs noticeably from that characterizing the European type of *Pseudotoma*, the remaining features of the shell agree very well, and we may conclude that *heilprini* represents the genus in the American Tertiary, but the species figured by Cossmann under the name *Pseudotoma bonellii*, is certainly generically different from *Ps. intorta* Broc., assumed as typical of *Pseudotoma*.

### **Ruscula** n. gen.

The general form of the shell in this genus is short and stout, with a very short stout reflexed beak, rather abruptly

formed below the convexity of the body whorl, and a spiral sculpture of coarse subequal lyrae. The embryo is conoidal, compact and closely coiled, multispiral, or composed of about three whorls. The body whorls are evenly convex and coarsely ribbed, the subsutural collar not well defined. The columella is biplicate. The two species before me are both from the Upper Claiborne ferruginous sand, and may be defined as follows: —

Form very stout, the spiral lyrae coarser and more close-set, separated by scarcely their own width on the peripheral convexity, though widely separated below on the body whorl; columellar plicae moderately strong and extremely oblique. Length of a specimen of 5 body whorls, 17.5 mm.; width, 7.5 mm. [*Fusus*].....**plicata** Lea

Form less stout, smaller in size, the spiral lyrae finer, separated by about twice their width on the convexity of the body whorl, the central of the fine intermediate threads more pronounced than in *plicata;* columellar plicae very strong and much less oblique. Length of an equally well grown specimen of 5 body whorls, 13.5 mm.; width, 5.5 mm.....**extricata** n. sp.

### **Varicobela** n. gen.

The shell here is of moderately large size, thick substance and very stout form, with strongly elevated rounded varices, usually about five in number on the first four body whorls. The embryo is large, broadly and regularly conoidal, much wider than high and composed of about three whorls. The body whorls are broadly and evenly convex, without pronounced peripheral prominence, having numerous long and rather narrow, elevated and obliquely sigmoid ribs and many fine lines of growth, which are cut by equally fine and regular spiral threads, producing a regular but very minute clathration; every fourth spiral thread is larger, these becoming strong and widely spaced lyrae on the body whorl below the convexity; aperture half as long as the shell, oblique, the canal very short but narrow and rather well differentiated. The inner lip is callous throughout and there are no columellar plicae. The type of this genus, rendered very isolated by the varices so unusual in the Pleurotomidae, is the *Strombus smithi*, of Aldrich, occurring in the upper Eocene strata at Red Bluff, Miss. A specimen of 4

body whorls measures 27 mm. in length and 12.5 mm. in width. The embryo is of the same general type as in *Pseudotoma*, as figured by Cossmann.

**Fusitoma** n. gen.

The type of this genus is *Fusitoma sipho*, a rather elongate, fusiform and moderately stout shell with somewhat thin walls, originally assigned to the genus *Fusus*. The aperture is feebly oblique and half as long as the shell, the canal very short and not differentiated from the aperture, of which it forms the gradually narrowed anterior end. The base is very gradually and sinuately narrowed below the broad convexity of the body whorl. The body whorls are broadly convex, becoming concave above near the suture, the latter feebly margined beneath. The ribs are obsolete, being replaced by long fine elevated lines apparently produced by arrested growth and crossed by somewhat conspicuous lyration. The embryo in my single example — which I owe to the kindness of Mr. Aldrich — is not in good condition, so that I cannot venture to describe it.

There have been some other species described and figured from the American Eocene, which may form genera in this tribe or enter some of those already defined and particularly *Fusitoma;* among these may be mentioned *Pl. leania* and *Pleurotomella sigma*, of Harris, *Pleurotoma capax* Whitf., *Fusus whitfieldi* Ald., and perhaps *Fusus harrisi*, of the latter author. I have not been able to study any of these species except by published drawings and descriptions.

Donovaniini.

The genus *Donovania* Bucq. (=*Lachesis* Risso; nom. praeocc.) is one of those doubtful forms which have been assigned widely different positions in the Gastropod series, and is included here as forming a distinct tribe of Pleurotomidae merely for the sake of completeness, and not because I have been able to make any investigations leading to personal con-

viction regarding its affinities. It is held to be a Pleurotomid by Tryon and Cossmann, but some other authors apparently consider it more closely affiliated with *Buccinum*. In *Donovania* the shell is very small in size, generally slender, with four or five body whorls which are evenly and feebly convex from suture to suture and without trace of fasciolar surface. The sculpture is strong and relatively very coarse, either simply clathrate or with rounded ribs, the coarse spiral lyrae mutually equal and some four in number. The aperture is short, from distinctly less to decidedly more than a third as long as the shell and is broadly oval. The canal is extremely short but rather well differentiated and the embryo is relatively large in size, hemispherical, smooth and paucispiral. It inhabits the present European seas.

It is stated by Cossmann that the genus *Nesaea*, of Risso, which, being preoccupied, was named *Chauvetia* by Monterosato, is synonymous with *Donovania* and that the *Folinaea*, of Monterosato, founded upon *Buccinum lefebvrei* Marav., is also synonymous, but, as Cossmann states — after Tryon — that *Donovania* in its broad sense occurs not only in the Mediterranean but in Japan, the East Indies and the Island of St. Paul, it is probable that there are a few really distinct genera confounded under that name, which lack of material and complete literature of the subject prevent me from investigating at present. *Donovania minima*, the type of the genus, according to Bellardi and Cossmann, occurs also in the Italian Pliocene and Post-pliocene strata, being described from the former under the name *Lachesis brunnea* Donov. The association of *Donovania* with *Bela*, which has been suggested, appears to me to be wholly unwarranted.

### Daphnellini.

This enormous complex, one of the largest of the Gastropod series, is composed of moderately small to minute species, occupying diversified environments throughout the globe, but particularly abundant in the Indo-Pacific region and wonderfully developed near New Caledonia. In comparison with known living forms, the fossils are very few in number and

occur, for the most part, in middle and upper Tertiary strata. The numerous genera cluster about certain apparently isolated type forms such as *Clathurella*, *Glyphostoma*, *Cythara*, *Mangelia*, *Daphnella* and *Raphitoma*, which differ so greatly among themselves as to suggest the propriety of subtribal division, but after long and patient study of rather large material I have been unable to devise a system of characters to serve for the definition of these subtribal groups. *Cythara*, in its typical forms, is a rather heavy shell, sometimes reminding us of the Conidae, having a long oblique linear aperture and well developed labial plicae, but other forms occur in which the linear aperture shortens by degrees and becomes devoid of folds, giving us the conditions observed in *Mangelia*. Others, having a short but gradually more oval and pliciferous aperture, merge from *Mangelia* into *Glyphostoma* and these into *Clathurella*, which is a larger and more obese form with thinner shell substance, and *Clathurella* again into *Raphitoma* and *Bellardiella*, which usually have a thin non-plicate outer lip, and *Daphnella*, with very thin fragile shell walls and absence of the true ribbing so universal in the remainder of the tribe. The short or obsolete beak of *Daphnella* becomes elongate in *Teres* and still longer in *Pleurotomella*, and, in *Eucyclotoma* Boettg., we have, as frequently occurs, a remarkable special structure of the shell as well as an embryo differing radically from that of *Daphnella*, to which it is allied by the absence of true ribbing.

These various transitions are made through more or less small but abrupt differentials, indicating intermediate generic a subgeneric groups, but the genera are so numerous in proportion to the known species, that one may well hesitate to define them, although it should be stated that if these intermediate stages are not characterized as genera it will be impossible to set any definite limits to the principal genera named above. When fuller series of species shall have been collected throughout the world and scientific workers become more discriminating than at present, generic names will certainly have to be given a very large number of these remarkable type forms, but at the present time little or no use-

ful result could be attained by pursuing such a course. Monterosato has attempted it in a partial manner in the case of the Mediterranean Daphnellids, but his genera, which in my opinion will be proved ultimately valid, have been suppressed by Cossmann and others.

The name Daphnellini is here adopted for the tribal designation, though the name *Daphnella* is antedated by both *Cythara* and *Mangelia*, because both of the latter have been called in question. Cossmann rejects *Cythara* altogether in favor of *Eucithara* Fisch., and *Mangelia* is generally spelled "*Mangilia*" by recent authors. These courses are both erroneous, however, since there is no necessity for the substitution of *Eucithara* for the former, and the original spelling of the latter is *Mangelia*, which being the case, it is impossible to change it, in spite of the fact that the one intended to be honored in the name loses this honor by reason of the mistake.

The two genera described below are both widely isolated in the structure of the embryo and in other characters: —

**Eoclathurella** n. gen.

The shell in this genus is small in size, more or less elongate, having when mature about three convex body whorls, the aperture oblique and rather narrow, oval or sublinear, much less than half as long as the shell, the sinus relatively large, deep, semicircularly rounded, strongly everted and well separated from the suture, the posterior callous prominence well developed. The inner lip is callous throughout, bearing three or four short transverse plicae at maturity, the canal very short and generally not strongly differentiated. The ribs are numerous, elongated and extend in gradually reduced form to the suture above, the spiral lyrae rather small and widely separated, but abruptly formed and slightly enlarged on the ribs, the fasciolar surface convex, crossed by the ribbing but having finer and more close-set spirals. The embryo it relatively large, broadly conical, closely coiled and of between three and four whorls, the lowermost gradually acquiring some longitudinal riblets which merge gradually

into the ribs of the subsequent whorls. The two species in my cabinet may be readily identified as follows: —

Form slender; shell substance thinner; obtuse periphery of the whorls well above the middle and broadly rounded, scarcely differentiable from the general convexity; lyrae small in size, finer but scarcely more close-set above the periphery; ribs small, somewhat oblique, close-set and numerous, some eighteen in number; callus of inner lip distinct and with a fine free edge throughout; outer lip not distinctly modified within. Length, 4.5 mm.; width, 1.5 mm. Jacksonian Eocene of the Red River Kimbrel bed.....**jacksonica** n. sp.

Form stouter and with thicker walls, the periphery of the whorls at about the middle and broadly, faintly angulate in profile; lyrae rather strong and more noticeably dilated on the ribs, almost completely obsolete between the latter and much finer above the periphery; ribs much larger, rounded, longitudinal, about twelve in number; callus of the inner lip almost obliterated for a short distance below the strong prominence at the posterior part of the outer lip; inner surface of the latter prominent with obtuse callus near the sinus and also in a longitudinal subbasal ridge, and with one or two minute folds between the two large prominences. Length, 5.0 mm.; width, 1.8 mm. Jacksonian Eocene of the Montgomery bed, La.....**obesula** n. sp.

The species described by Meyer, from the Upper Claiborne sand of Alabama, under the name *Mangelia meridionalis*, undoubtedly belongs to this genus. It differs from the species above described in having two rounded and two carinated smooth embryonic whorls and five body whorls, and even with this number of whorls, which may be a mistake of the describer, the figured type seems to be immature, as the columellar folds do not appear and the outer lip is not of an adult type; it is materially larger than either of the species described in the table. This genus represents the oldest type of non-operculate Pleurotomidae known to me at present.

### **Helenella** n. gen.

This generic name is proposed for certain very small species apparently confined to the fauna of St. Helena, though possibly extending to the entire West African faunal province and having a form of embryo wholly different from anything else in the tribe. The shell is oval or fusiform, moderately thick in substance, closely, spirally nodulose in

sculpture, having the aperture oblique, narrowly oval, nearly half as long as the shell and completely undifferentiated from the extremely short canal. The anal sinus is small but distinct and abruptly formed; it is but slightly everted from the axial line of the aperture, though separated from the suture by a thickened callus. The outer lip is not dilated and is non-plicate. Columella with about two broadly tumid oblique and approximate folds at the middle. The spire is half as long as the shell, with its outline even in profile from whorl to whorl, and without break due to individual convexity of the whorls, the side profile of each whorl very feebly arcuate, the sutural breaks in the curve of profile narrow; each whorl with about three very broad approximate spiral lyrae, forming moderately elevated tubercles or nodules on the numerous approximate ribs; pillar not differentiated, the base of the shell obconic. The embryo is smooth, of between one and two whorls, very broadly and obliquely obtuse at apex in profile, the summit concave, the nucleus extremely small. Body whorls three to four in number. The two species in my cabinet are the following:—

Shell white, variegated irregularly with dark brown; longitudinal ribs separated by much less than their own widths and very numerous, some twenty in number. Length, 4.0 mm.; width, 1.6 mm.
**multigranosa** Smith

Shell still smaller, clear and pale straw color throughout, the ribs separated by fully their own widths and about fifteen in number, much more nearly obliterated between the strong spirals than the latter are between the ribs. Length of a specimen of 3 body whorls, 2.9 mm.; width, 1.3 mm.
**insolens** n. sp.

The general outline of the shell in this genus is not unremindful of *Mitromorpha*, but it differs in having a distinct anal sinus. Probably many other species will be discovered, hitherto overlooked because of their minute size.

## Taranini.

This tribe, though very limited in scope, is altogether isolated and differs from the preceding not only in facies, but in some important structural features, the most important

being the very broad shallow anal sinus situated on the periphery and not on or near the suture, which is its invariable position in the Daphnellini. The only genus at present known is *Taranis* Jeffr., a very minute and fragile shell, with the aperture broadly oval and the canal very short. The surface is clathrated by equal longitudinal and spiral raised lines and is without trace of true ribs. The body whorls are about three in number. No extinct species of *Taranis* is known from the European strata, but, singularly enough, a species which, from the figure, appears to be a true *Taranis*, was described by Prof. Harris from the middle Eocene strata of Smithville, Texas, under the name *finexa* (Proc. Ac. Nat. Sci., Phila., 1895, p. 64). This is one of the most interesting discoveries yet announced among our extinct Gastropods.

### Mitromorphini.

The species of this tribe are very small, oval or fusiform in outline and generally strongly, spirally sculptured. The aperture is long and more or less narrowly oval, and, owing to the fact that the anal sinus is obsolete, some doubt exists as to their true relationship. In placing the tribe provisionally with the Pleurotomidae I merely follow the usual custom, having made no determinative studies myself. The species seem to be few in number and individually rare or, at least, but few exist in any collection accessible to me at present. The only representative in my cabinet has the apex of the shell worn away so that I am unable to describe the embryo, except in general terms as shown in the West Indian fossil forms described by Dr. Dall, in which it appears to be small, rounded or obtuse and paucispiral.

Species of *Mitromorpha* have been described from Japan, California, the Pliocene strata of Florida and the European Pliocene, the latter, the *subulata* of Cossmann, apparently being a typical member of the genus; so its distribution, though limited to the northern temperate regions as far as known, is, or has been, very extended. The columella is sometimes bi- or triplicate at the middle, and the outer lip is,

at least occasionally, finely plicate within throughout its length. The species described by Dr. Dall from the Florida Pliocene under the name *pygmaea*, will probably form a genus or subgenus different from the purely lyrate species including *cincta* Dall from the same beds, as well as *lirata* Ad., assumed as the type of *Mitromorpha*. This genus has recently been assigned to the Mitridae by Dall (Trans. Wag. Inst., Vol. 3, p. 95).

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Transactions of The Academy of Science of St. Louis.

VOL. XIV. No. 6.

# THE GENUS OTHAKE RAF.

B. F. BUSH.

*Issued June 8, 1904.*

JUN 22 1904

# THE GENUS OTHAKE RAF.*

B. F. Bush.

While going over some specimens of *Polypteris* collected in Texas by Mr. J. Reverchon about a year ago, I felt convinced that there were more than three annual species in the collection, and began a study of the genus to ascertain just what species the specimens under consideration represented, which study has been continued as my spare time permitted, up to the present.

Through the courtesy of Prof. Wm. Trelease and Mr. Richard Rathbun, I have been enabled to make a careful examination of all the material of the species generally referred to this genus in the herbarium of the Missouri Botanical Garden and that of the United States National Herbarium,† and I have concluded that it is better to treat the species of the Southwestern United States as a separate genus from the Southeastern plant on which Nuttall founded the genus *Polypteris*.‡

As it became apparent to me that the annual species, of which *Stevia callosa* § may be taken as the type, must bear another name, I began to examine the synonymy of *Polypteris* to ascertain if anyone had described the species under a separate name.

The earliest name to be applied to this group of plants appears to have been given by Rafinesque, who in the New Fl. Am. 4 : 73, 1836, takes up the *Stevia callosa* of Nuttall

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* Presented by title before The Academy of Science of St. Louis, May 2, 1904.

† For the sake of convenience, I have used the letters M and N to signify specimens from the herbarium of the Missouri Botanical Garden, and the United States National Herbarium respectively.

‡ Nuttall, Gen. 2 : 139. 1818.

§ Nuttall, Journ. Acad. Philad. 2 : 121. 1821.

under the name *Othake*. As Rafinesque's New Flora is an exceedingly rare book, I append his original description.

"OTHAKE Raf. diff. *Stevia*, perianthe turbinate sub 8 flos, segments about 8-nervose, florets with slender tube, limb as long, 5-parted, anthers subsessile, style elongate, hispid, stigmas revolute, seeds elongate, as long as perianth, obverse pyramidal, 4-gone, awned by 8 teeth, or short scariose scales, annuals, leaves alternate and callose, flowers paniculate, incarnate. This G. is perfectly distinct by the perianthe, deep cut florets, scaly crown, leaves, &c. The name means warty apex, the leaves ending in obtuse callosity.

"923. *Othake tenuifolium* Raf. *Stevia callosa* Nutt. Stem terete, furfurescent, glandular above, leaves narrow linear, thickish, with appressed hairs, panicle dichotome multiflore lax divaricate — in Arkansas: pedal leaves uncial often with fascicles at the axils, flowers on long naked peduncles; the segments of the florets narrow, long linear, acute, segments of perianthe cuneate, acuminate."

Rafinesque in the above clearly refers Nuttall's *Stevia callosa* to his new genus, but unfortunately replaces Nuttall's name by one of his own, which cannot be retained for the species. Rafinesque also describes a second species of *Othake* under No. 924, which he says was collected in Arkansas also by Nuttall, but I have been unable to identify it from his meager description. The only points, in the description of this second species, which are significant, are the broader and longer leaves, the lower of which are often opposite.

After a very careful study of all the species that are commonly included in the genus POLYPTERIS, I unhesitatingly offer the following arrangement: —

Perennial; bracts of the involucre more imbricated and scarious, glabrous; corolla with the base of 5-parted limb forming a short campanulate throat: Southeastern United States. 1. POLYPTERIS Nuttall.

Annual; bracts of the involucre few-imbricated, herbaceous up to the sphacelate colored tips, pubescent or glandular; corolla 5-parted nearly down to the slender tube: Southwestern United States and Mexico. 2. OTHAKE Rafinesque.

### 1. POLYPTERIS Nutt. Gen. 2: 139 (1818).

One species only, *P. integrifolia* Nuttall, l. c. of the Southeastern United States.

2. Othake Rafinesque, New Fl. Am. **4**: 73 (1836).

*Stevia* Nuttall, Journ. Acad. Philad. **2**: 121 (1821), not Stevia Cav. Ic. **4**: 32. *t. 354–356* (1797).

*Palafoxia* DC. Prodr. **5**: 124 (1836), not Palafoxia Lag. Nov. Gen. & Spec. 26, 181 (1816).

*Florestina* DC. Prodr. **5**: 655 (1836), not Florestina Cass. Bull. Philom. **1815**, and Dict. **17**: 155. *t. 86* (1820).

*Palafoxia* T. & G. Fl. N. A. **2**: 368, 369 (1842), not of Lag. Nov. Gen. & Spec. 26, 181 (1816).

*Polypteris* Gray, Proc. Am. Acad. **19**: 30 (1883), not Polypteris Nuttall, Gen. **2**: 139 (1818).

Erect, rough, glandular, canescent or cinereous branching annual herbs, with alternate, mostly entire leaves, or the lower opposite and slenderly petioled, and corymbose or paniculate, pedunculate heads of tubular, or both tubular and radiate pink or rose-purple flowers. Involucre campanulate or obconic, its bracts in 1 or 2 series, narrow, herbaceous, nearly equal, or with a few exterior shorter ones, appressed, usually colored, at least at the narrow sphacelate tips. Receptacle small, flat, naked. Ray-flowers, when present, pistillate, fertile, the rays 3-cleft, but sometimes abortive or wanting. Disk-flowers perfect, fertile, their corollas with slender tubes and deeply 5-parted campanulate limbs. Anthers entire or emarginate at the base. Style-branches filiform, acutish, glandular-pubescent throughout. Achenes linear or narrowly obpyramidal, quadrangular, usually pubescent or hairy. Pappus of 6–12 lanceolate, often strongly costate scales, that of the outer achenes as numerous, often much shorter, oblong or spatulate, obtuse, erose or fimbriate. Southwestern North American scabrous-pubescent, annual herbs, penetrating Mexico, flowering spring, summer and autumn.

The species fall naturally into two sections, the first with homogamous heads containing one-half of the species, not considering the Mexican species, which may here be mentioned as Othake Lindenii, the *Polypteris Lindenii* of Gray, Pl. Wright. **1**: 120, 1852, and the second section with heterogamous heads, containing the remainder. For the North American species I offer the following: —

ANALYSIS OF SPECIES.

Heads homogamous, middle-sized or small, 4–8 mm. high; involucre turbinate; achenes much broadened upward, 3–6 mm. long.

Stems zigzag, slender, much branched, the branches widely diverging, whitish, glaucous; leaves very narrow, linear, 1-nerved, thickish; heads smallest, flowers flesh-colored; peduncles short, slender, densely glandular. 1. OTHAKE CALLOSUM.

Stems straight, slender, few-branched, branches ascending; leaves broader, linear-lanceolate, 1-nerved; heads somewhat larger, more numerous flowered, flowers bright rose-colored; peduncles very slender, longer, scabrous and glandular. 2. OTHAKE ROSEUM.

Stem stout, straight, little branched, branches ascending; leaves broadest, ovate-lanceolate, thin, 3-nerved; heads large, many-flowered, flowers rose-purple; peduncles short, stout, somewhat glandular. 3. OTHAKE TEXANUM.

Heads heterogamous, middle-sized or large, 1–2 cm. high; involucre obconic; achenes slender, linear, scarcely broadened upward, 4–8 mm. long; bracts of the involucre hispid and glandular.

Heads largest; involucral bracts 1 cm. or less long; leaves indistinctly 3-nerved, lower opposite; peduncles very stout, densely scabrous-pubescent. 4. OTHAKE HOOKERIANUM.

Heads middle-sized; involucral bracts 1–2 cm. long or longer; leaves all alternate, distinctly 3-nerved; plants densely glandular all over; peduncles stout. 5. OTHAKE MAXIMUM.

Heads smaller; involucral bracts shorter; leaves smoother, indistinctly 3-nerved; plants minutely scabrous or nearly smooth; peduncles long, very slender, diverging, sparingly glandular. 6. OTHAKE REVERCHONI.

## 1. OTHAKE CALLOSUM (Nutt.) Bush.

*Stevia callosa* Nutt. Journ. Acad. Philad. **2**: 121 (1821).
*Florestina callosa* (Nutt.) D.C. Prodr. **5**: 655 (1836).
*Othake tenuifolium* Raf. New Fl. Am. **4**: 74 (1836).
*Palafoxia callosa* (Nutt.) T. & G. Fl. N. A. **2**: 369 (1842).
*Polypteris callosa* (Nutt.) Gray, Proc. Am. Acad. **19**: 30 (1883).

Stems slender, widely much branched, appressed strigose-pubescent, glandular above, 2–6 dm. high. Leaf-blades very narrow, linear, thickish, obtuse or acutish, rough on both sides, the upper alternate, the lower opposite and short-petioled, 1-nerved, the edges revolute, 2–5 cm. long, 1–3 mm. wide, the upper gradually reduced. Involucre campanulate, 3–4 mm. high, its bracts linear, 3–4 mm. long, appressed, canescent, eglandular or rarely glandular, in two series, both

much alike, the inner but little colored. Peduncles slender, short, densely stalked-glandular; ray-flowers none; disk-flowers 5–12, perfect, fertile, 5-parted nearly to the filiform tube, flesh-colored; achenes 3–4 mm. long, narrowly obpyramidal, angular, pubescent or rarely glabrous; pappus-scales 6–8, obovate or spatulate, erose or dentate, about 1 mm. long, the costae scarcely reaching the apices. — Rocky barrens and plains, Missouri and Arkansas to Texas and New Mexico. Autumn.

*Specimens examined:* Missouri: Marble Cave, *Trelease*, September 11, 1898 (M); Swan, *Bush* 476, September 24, 1899 (M N); *Trelease*, October 9, 1899 (M); Greene County, *Bush* 203, September 4, 1893 (M N); Eagle Rock, *Bush* 115, September 17, 1896 (M N); *Mackenzie*, September 17, 1896 (M). Arkansas: Eureka Springs, *Wislizenus*, August, 1887. Texas: Dallas, *Bush* 1635, October 30, 1900 (M); 1146, September 26, 1900 (M); *Hall* 356, June 30, 1872 (M N); *Reverchon* 3288, October 16, 1902 (M); 526, August, 1882 (N); Southwest Texas, *Palmer* 656, September, 1879, to October, 1880 (N); Fort Worth, *Ward*, September 9, 1877 (N); *Bodin* 96, July, 1889 (N); Glen Rose, *Ward*, October 10, 1891 (N); Comanche Peak, *Reverchon* 3655, September 6, 1903; Weatherford, *Tracy* 8142, October 18, 1902 (M); Parker County, *Broadhead*, date of collection not given (M); Willow Creek, *Jermy* 804, date not given (M N); Kerrville, *Heller* 1919, June 26 to 30, 1894 (N); Valley of the Rio Grande, below Dona Ana, New Mexico, *Mexican Boundary Survey* 613 (N); Western Texas, *Wright* 377, May to October, 1849 (N). New Mexico: No locality, *Wright* 1410, 1851–52 (N).

2. Othake roseum Bush.

Stems erect, simple or few-branched, branches ascending, scabrous-pubescent, 4–7 dm. high. Leaf blades linear-lanceolate, entire, acute or acuminate, narrowed at the base, rough on both sides, the upper alternate, the lower opposite and short petioled, 2–5 cm. long, 2–5 mm. wide, 1-nerved, the upper gradually reduced. Involucre campanulate, 6–9 mm.

high, its bracts 5–7 mm. long, hispid and glandular, in two series, the outer more herbaceous, and colored only at the tips, the inner deep purple for at least the upper half. Peduncles slender, ascending, scabrous-pubescent and glandular; ray-flowers none; disk-flowers numerous, perfect, fertile, 5-parted nearly to the filiform tube, bright rose-colored, pubescent on the inner surface near the apices; achenes 3–4 mm. long, scarcely 1 mm. thick, linear, slightly broadened upward, pubescent; pappus-scales 6–8, lanceolate, acute, more than one-half the length of the achene, those of the marginal flowers spatulate, obtuse, shorter, strongly costate, the costae not reaching the tips, all densely pubescent. — Sandy prairies and woods, Eastern Texas and Indian Territory. Summer and autumn.

*Specimens examined:* Texas: Sheldon, 18 miles east of Houston, *Reverchon* 3656, October 7, 1903, type (M); Houston, *Bush* 1599, October 25, 1900 (N); Columbia, 50 miles south of Houston, *Bush* 1387, October 7, 1900 (M N); Brazos County, *Pammel*, July 1888 (M); Dallas, *Glatfelter*, June 16, 1898 (M); *Reverchon* 1507, date of collection not given (N); 3290, May 1, 1902 (M); Galveston Bay, *Joor*, September 26, 1884, in part, the larger plant (M); Laredo, *Pringle* 2655, July 24, 1889 (M); Millett, *Trelease*, November 4, 1897 (M); no locality, *Lindheimer* 106, 1843 (M); Hockley, *Thurow* 12, 1890 (N); Austin, *Letterman*, August, 1882 (N); Industry, *Wurzlow* 35, 1894 (N); Cherokee, Rusk County, *Joor*, October 31, 1884, in part, the larger plant. Indian Territory: Canadian River, *Bigelow*, 1853–54 (N).

3. Othake Texanum (DC.) Bush.

*Palafoxia Texana* DC. Prodr. **5**: 125 (1836).
*Polypteris Texana* (DC.) Gray, Proc. Am. Acad. **19**: 31 (1883).

Stems stout, dichotomously branched, hispid or scabrous-pubescent, slightly viscid above, 2–6 dm. high. Leaf-blades lanceolate or ovate-lanceolate, entire, obtuse, rounded at the base, rough on both sides, the upper alternate, the lower opposite and slender-petioled, 2–5 cm. long, 10–25 mm. wide,

the upper much reduced, distinctly 3-nerved. Involucre campanulate, 6–12 mm. high, its bracts 5–10 mm. long, linear, hispid or canescent, in two series, the outer nearly herbaceous, the inner thinner and with rose-colored tips. Peduncles erect, stout, short, densely scabrous and somewhat glandular; ray-flowers none; disk-flowers numerous, perfect, fertile, 5-parted nearly to the filiform tube, rose-colored; achenes 5–7 mm. long and about 1 mm. thick, narrowly obpyramidal, quadrangular, pubescent; pappus-scales 6–8, short-ovate, obovate or spatulate, erose or fimbriate, very short. — Sandy woods and prairies, Indian Territory to Texas and Mexico. Spring, summer and autumn.

*Specimens examined:* Indian Territory: Quanah's Ranch, *Sheldon* 197, July 25, 1891 (N). Texas: Laredo, *Reverchon* 3657, March 26, 1903 (M); *Mackenzie* 7, August, 1899 (M); Pena Station, near Laredo, *Havard*, August, 1884 (N); Southwestern Texas, near Laredo, *Palmer* 642, September. 1879, to October, 1880 (M N); Corpus Christi Bay, Nueces County, *Heller* 1562, April 9 to 12, 1894 (M N); Nuecestown, *Marlatt*, April 27, 1896 (N); Millett, *Trelease*, November 5, 1897 (M); Eagle Pass, *Havard* 56, date of collection not given (N); Valley of the Rio Grande, below Dona Ana, New Mexico, *Mexican Boundary Survey* 614, in part, two sheets of this collection, the smaller plant on each sheet (N). Mexico: Monterey, *Pringle* 1919, July 4, 1888 (N); Coahuila and Nuevo Leon States, *Palmer* 645, February to October, 1880 (N); Tampico, Tamaulipas, *Pringle* 6354, April 4, 1896 (M).

4. Othake Hookerianum (T. & G.) Bush.

*Othake longifolium* Raf. New Fl. Am. 74 (1836). (?)

*Palafoxia Texana* Hook. Ic. Pl. *t. 148* (1837), not of DC. Prodr. **5**: 125 (1836).

*Palafoxia Hookeriana* T. & G. Fl. N. A. **2**: 368 (1842).

*Polypteris Hookeriana* (T. & G.) Gray, Proc. Am. Acad. **19**: 31 (1883).

Stems stout, branched, hispid, glandular-pubescent and viscid above, 2–6 dm. high. Leaf-blades linear-lanceolate, entire, acute or acuminate, narrowed at the base, rough on both sides, the upper alternate, the lower opposite and

slender petioled, 3–10 cm. long, 6–10 dm. wide, the upper gradually reduced, indistinctly 3-nerved. Involucre obconic, or cylindrical, 10–25 mm. high, its bracts 6–15 mm. long, linear, glandular, in two series, the outer looser and often wholly herbaceous, the inner with purplish tips. Peduncles erect, stout, short, densely scabrous-pubescent and glandular; ray-flowers 8–10, pistillate, fertile; rays rose-purple, deeply 3-cleft, 1–2 cm. long, sometimes small or none; disk-flowers numerous, perfect, fertile, 5-parted nearly to the filiform tube, purplish; achenes 6–8 mm. long and about 1 mm. thick, linear, very pubescent; pappus-scales of the disk-flowers 6–8, lanceolate, awned by the excurrent costae, more than half the length of the achene, those of the ray-flowers as many, spatulate, obtuse, very short. Sandy plains and prairies, Nebraska and Kansas to Texas, New Mexico, Colorado and Mexico. Summer and autumn.

As this is the only other species Nuttall collected in Arkansas, it may be inferred that this is the *Othake longifolium* of Rafinesque. If such should prove to be the case, Rafinesque's name is some six years earlier than that of Torrey and Gray.

*Specimens examined:* KANSAS: American plains, Lat. 40, *Hall*, 1864 (M N); Caldwell, *Carleton*, 340, July, 1891 (N); *Smyth* 271, September 10, 1890 (N); Arkalon, *Kellerman* 4, June 28, 1888 (N); *Carleton*, October 23, 1892 (N); Garden City, *Smyth* 171, August 20, 1890 (N); Hamilton County, *Hitchcock* 288, August 3, 1895 (M N); Syracuse, *Thompson* 76, July 4, 1893 (M N). INDIAN TERRITORY: Cimarron River, *Mark White* 152, 250, July 12, 1899 (M); on the False Washita, *Palmer* 446, 1868 (N); on the Canadian River, *Bigelow*, 1853–54 (N). COLORADO: Greeley, *Ward*, August 3, 1881 (N); no locality, *Parry* 352, 1864 (N). NEW MEXICO: Mesilla, Donna Ana County, *Wooton* 28, June 17, 1897 (M N); Las Cruces, *Wooton*, August 22, 1893 (N); *G. R. Vasey*, 1881 (N); Roswell, *Earle* 381, August, 1900 (N); no locality, *Wright* 1250, 1851–52 (N). TEXAS: Millett, *Trelease*, November 5, 1897 (M); Milano, *Joor* 54, October 28, year not given (M); Big Springs, *Tracy*

872, May 11, 1902 (M); Corpus Christi Bay, Nueces County, *Heller* 1562, April 9–12, 1894 (M); Hueco Tanks, *Mulford* 136, July 2, 1895 (M); Southwestern Texas, *Palmer* 655, September, 1879, to October, 1880 (N); Odessa, *Havard*, September, 1881 (N); no locality, *Havard*, September, 1881 (N); El Paso, *Wright* 375, October, 1849 (N); Valley of the Rio Grande, below Dona Ana, New Mexico, *Mexican Boundary Survey* 615, three sheets of this collection and number (N); same locality and collection, *Mexican Boundary Survey* 614, in part, two sheets of this number, the larger plant on each (N). Mexico: Paso del Norte, Chihuahua, *Pringle* 761, September 20, 1886 (N).

5. Othake maximum (Small) Bush.

*Polypteris maxima* Small, Fl. Southeastern U. S. 1288 (1903).

Stems stout, simple below, few branched above, densely hispid-scabrous and glandular throughout, 8–10 dm. high. Leaf-blades linear-lanceolate, entire, acute or acuminate, narrowed at the base, rough on both sides, all alternate, 5–10 cm. long, 1–2 cm. wide, the upper gradually reduced, distinctly 3-nerved. Involucre campanulate, 1–2.5 cm. high, its bracts 1–2 cm. long, linear, densely white-hispid and glandular, in two series, the outer wholly herbaceous, the inner thinner and somewhat colored at the tips. Peduncles ascending, stout, densely hispid and glandular; ray-flowers 8–12, pistillate, fertile; rays purplish or rose-colored, deeply 3-cleft, 1–2 cm. long; disk-flowers numerous, perfect, fertile, 5-parted nearly to the filiform tube, purplish or rose-colored; achenes 6–8 mm. long, scarcely 1 mm. thick, linear, quadrangular, hairy; pappus-scales of the disk-flowers 6–8, lanceolate-awl-shaped, awned by the excurrent costae, very pubescent, as long as the achene itself or longer, those of the ray-flowers as many, similar and but little shorter. — Southern Texas. Autumn.

*Specimens examined:* Texas: Industry, *Lindheimer* 266, August, 1844 (M N).

6. Othake Reverchoni Bush.

Stems nearly simple, sparingly appressed-pubescent, few-branched, the branches very slender, short-pubescent or glabrate, widely diverging, 4–8 dm. high. Leaf-blades linear-lanceolate, entire or slightly undulate, acute or acuminate, narrowed at the base, minutely scabrous on both sides, the upper alternate, the lower opposite and manifestly petioled, 3–6 cm. long, 3–6 mm. wide, the upper gradually reduced, distinctly 3-nerved. Involucre obconic, 8–12 mm. high, its bracts 6–10 mm. long, loosely pubescent and glandular, in two series, linear, the outer looser and herbaceous, the inner purplish colored. Peduncles very slender, terminating slender diverging branches, pubescent and sparingly glandular; ray-flowers 3–6, pistillate, fertile; rays rose-colored, 1–1.5 cm. long, deeply 3-cleft; disk flowers 3–6, perfect, fertile, 5-parted nearly to the filiform tube, purplish; achenes 4–5 mm. long, scarcely 1 mm. thick, linear, angled, hairy; pappus-scales of the disk-flowers 6–8, narrowly lanceolate, 4–5 mm. long, about as long at the achene, the mid-vein extending into a long rough cuspidate point, those of the ray-flowers as many, oblong-spatulate, 1 mm. long, erose or dentate at the tips. — In dry sands, Eastern Texas. Autumn.

*Specimens examined:* Texas: Big Sandy, Upshur County, *Reverchon* 3289. September 16, 1902, type (M); Cherokee, Rusk County, *Joor*, October 3, 1884, in part, the smaller plant (M); Evergreen, Harris County, *Joor*, September 26, 1884, in part, the smaller plant (M).

*Issued June 8, 1904.*

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Transactions of The Academy of Science of St. Louis.

VOL. XIV. No. 7.

# THE TEXAS TRADESCANTIAS.

B. F. BUSH.

*Issued December 30, 1904.*

# THE TEXAS TRADESCANTIAS.*

B. F. Bush.

It has long been apparent to every one who has attempted to name specimens of Tradescantia by the Manuals and Floras of our country, that great diversities of forms were referred to the Linnean species, *Tradescantia Virginiana*.† Consequently we find quite a number of very unlike species bearing that name in our collections.

Having been familiar for many years with *T. reflexa*,‡ which appears to be the most widely distributed of all the forms of the so-called *T. Virginiana*, as well as the one most generally referred to *T. Virginiana* from which it is very different, I was very much struck by the different appearance of the more common species observed in Texas, during the several years that I was engaged in collecting in that State. My acquaintance with the other Missouri species, *T. occidentalis*,§ *T. brevicaulis*,‖ *T. pilosa*,¶ *T. Virginiana and T. bracteata*,** was but meager, although I had collected the last named species repeatedly during the last twenty years. These species are more or less restricted in range within the State, while *T. reflexa* is very common throughout its borders.

My attention and interest were more fully aroused in the species of this genus by the examination of some specimens collected in Eastern Texas by Mr. J. Reverchon in 1902 and 1903, and I clearly perceived that these specimens could not

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* Presented by title to The Academy of Science of St. Louis, November 21, 1904.

† L. Sp. Pl. 288. (1753).

‡ Raf. New Flora. 2 : 87. (1836).

§ Britton, Man. Nor. States and Can. 241. (1901).

‖ Raf. Atl. Jour. 150. (1832).

¶ J. G. C. Lehm. Nov. Act. Leop. 14. Part 2. *Pl.* 48. (1828).

** Small, Britton & Brown, Ill. Flora. 3 : 510. (1898).

be referred to any of the described species. I therefore began an examination of all the specimens of this genus collected in Texas which I had in hand, together with the mounted material of the herbarium of the Missouri Botanical Garden, and that of the United States National Museum,* which through the kindness of Dr. Wm. Trelease and Mr. Richard Rathbun, was placed in my hands for study. To these gentlemen, and especially to Dr. J. N. Rose, of the United States National Museum, who has long studied this genus and has kindly given me assistance, I am under many obligations.†

It may perhaps be considered by some that I have increased unnecessarily the number of species, but I have endeavored to be as consistent as possible in my treatment, and I am unable to refer the type specimens, upon which are based the following new species, to any of those already described.

Of the 18 species herein treated from Texas, such diverse species as *T. scopulorum*,‡ *T. Texana*,§ *T. occidentalis*, *T. reflexa*, *T. hirsuticaulis* ‖ and *T. humilis* ¶ have been referred to *T. Virginiana*, which in its typical form has not been detected in the State.

As understood by me, the plant upon which Linneus founded his *T. Virginiana* is well exemplified in such collections as *Lloyd*, Cincinnati, O., May 26, 1890, and *H. S. Milburn*, New Jersey, June 2, 1888, and ranges from Massachusetts and Connecticut to N[illegible] Carolina, Georgia and Mississippi, west to Wisconsin, Missouri and northern Arkansas, and is quite constant in having smooth stems, large flowers, and very wide, long leaves.

After a careful study of a large number of specimens, I offer for the Texas species the following: —

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* For the sake of convenience, I have used the letters M and N to signify specimens from the Herbarium of the Missouri Botanical Garden, and the United States National Herbarium, respectively.

† Since the above was written, I am under still further obligations to Dr. Rose, who has read the manuscript and has kindly made a number of corrections and changes in the paper.

‡ Rose, Contr. U. S. Nat. Herb. **5**: 205. (1899).

§ See below.

‖ Small, Bull. Torr. Bot. Club. **24**: 233. (1897).

¶ Rose, Contr. U. S. Nat. Herb. **5**: 204. (1899).

ANALYSIS OF SPECIES.

Leaf blades linear or linear-lanceolate, 12–50 times longer than broad, more or less involutely folded.

Stems short, 1-10 cm. long; bracts of the involucre mostly longer than the leaf blades.

Stems and leaves long-villous. 1. T. BREVICAULIS.

Stems and leaves roughish-pubescent. 2. T. HIRSUTIFLORA.

Stems and leaves appressed-pilose. 3. T. SUBACAULIS.

Stems 1-10 dm. long; bracts of the involucre mostly shorter than the leaf-blades.

Sheaths not imbricated at the base of stem.

Plants bright green; pedicels villous or glandular pilose; sepals villous or pilose, becoming membranous.

Stems villous; pedicels villous. 4. T. AUSTRALIS.

Stems glabrous; pedicels glandular pilose. 5. T. OCCIDENTALIS.

Plants glaucous; pedicels glabrous, glandular-pubescent or velvety; sepals often with a tuft of hairs at apex, leathery.

Pedicels glabrous; bases of the involucral bracts not sac-like.

Stems tall, robust; sepals glabrous, with a tuft of villous hairs at apex. 6. T. REFLEXA.

Stems medium height, slender, much branched; umbels numerous; sepals smooth. 7. T. SCOPULORUM.

Stems low, very slender, simple, unbranched; umbel single; sepals smooth. 8. T. WRIGHTII.

Pedicels pubescent.

Pubescence glandular; bases of the involucral bracts not sac-like. 9. T. VAGINATA.

Pubescence velvety; bases of the involucral bracts conspicuously sac-like. 10. T. GIGANTEA.

Plants yellowish. 11. T. HIRSUTICAULIS.

Stems hirsute with spreading brownish or whitish hairs.

Stems densely appressed-pilose. 12. T. REVERCHONI.

Sheaths much imbricated at the base of the stem.

Stems erect.

Minutely roughish-pubescent and glandular. 13. T. INTERMEDIA.

Conspicuously roughish-pubescent; not glandular. 14. T. EGLANDULOSA.

Stems diffusely spreading.

Stems scabrous-pubescent; leaf blades broader and longer than involucral bracts. 15. T. HUMILIS.

Stems appressed-pilose; involucral bracts broader and shorter than the leaf-blades. 16. T. TEXANA.

Stems roughish-pubescent; involucral bracts broader and much longer than leaf-blades. 17. T. DIFFUSA.

Leaf blades ovate to lanceolate, 2–10 times longer than broad, flat. 18. T. MICRANTHA.

1. Tradescantia brevicaulis Raf.

*Tradescantia brevicaulis* Raf. Atl. Journ. 150. (1832).
*Tradescantia pumila* Raf. Atl. Journ. 150 (1832).
*Tradescantia Virginica* var. *villosa* Wats. Gray, Man. ed. 6. 539. (1890).

Hillsides and rocky woods, Illinois and Southern Missouri to Kansas and Texas. April and May. Remarkable on account of the long villous involucral bracts.

*Specimens examined*: Missouri: Monteer, Shannon County, *Bush* 2571, June 29, 1888, an old plant in seed (M); 678, May 15, 1894 (M); 388, May 25, 1900 (M); Iron County, *Eggert*, May 12, 1893 (M); Webb City, *Bush* 1608, May 12, 1902 (M); *Palmer* 298, May 4, 1902 (M); Gad's Hill, *Russell*, April 25, 1898 (M): Silica, *Russell*, May 5, 1898 (M); no locality given, *Blankinship*, 1897 (N). Illinois: Mahaska, collector and date of collection not given (N). Kansas: Cowley County, *Mark White*, April, 1898 (M). Texas: Dallas, *Bush* 578, April 24, 1900 (M); *Reverchon* 4049, April, 1880 (M); Fort Worth, *Reverchon* 2771, April 1, 1902 (M); no locality, *Ward*, without date of collection (N).

2. Tradescantia hirsutiflora Bush sp. nov.

Stems short, stout, robust, 1–2 dm. tall, few-leaved, roughish-pubescent, especially above the upper sheath, pale yellowish-green; leaf-blades linear-lanceolate, 5–15 mm. wide, straight or often curved, conduplicate, roughish-pubescent and ciliate, mostly basal. Sheaths much overlapping, pubescent, ciliate with long hairs; bracts of the involucre 2, sometimes only 1 long one and several short ones, densely pubescent, the long one resembling the leaves. Cymes about 12- to 15-flowered; pedicels 2–3 cm. long, stout, densely hirsute with tawny hairs; sepals linear-lanceolate, obtuse, 12–18 mm. long, densely hirsute with tawny hairs; corolla large, bright blue. — Sandy soil, Eastern Texas. Spring.

Differs conspicuously from the preceding species in being roughish-pubescent, not villous, and in the hirsute pedicels and sepals.

*Specimens examined:* Texas: The only specimens seen

are those of the type, collected at Grand Saline, Van Zandt County, by *J. Reverchon* 2480, April, 1901 (M).

3. Tradescantia subacaulis Bush sp. nov.

Stems short, 1–2 dm. tall, often none, sometimes with one or two leaves, but usually much branched from the base and leafless, pale yellowish-green, appressed-pilose; leaf-blades linear-lanceolate, 5–15 cm. long, 5–15 mm. wide, somewhat curved, attenuate, softly appressed-pilose below, and ciliate with long hairs. Sheaths large, thin, inflated, the upper very short, all very smooth, except the uppermost; bracts of the involucre 2, very broad and saccate at the base, shorter, or sometimes longer than the leaf-blades, pilose below with long hairs, above with short hairs. Cymes about 10- to 30-flowered; pedicels 2–4 cm. long, densely pilose with whitish hairs; sepals linear-lanceolate, obtuse, 6–8 mm. long, densely pubescent; corolla small, pale blue. — Sandy soil, Eastern Texas. Spring.

*Specimens examined:* Texas: The only specimens seen are those of the type, collected at Dawson, Navarro County, by *J. Reverchon* 4054, April 16, 1903 (M).

4. Tradescantia australis Bush sp. nov.

Stems erect, simple, slender, sometimes branched, 2–4 dm. tall, pilose with long spreading white hairs; leaf-blades long-linear, acuminate, flat or rarely conduplicate, hairy like the stems; bracts of the involucre 2, very unequal, hairy like the leaves, and resembling them, minutely ciliate on the margins. Cymes about 10- to 15-flowered; pedicels 2–3 cm. long, densely pilose with simple white hairs; sepals linear-lanceolate, obtuse, 8–10 mm. long, densely pilose with simple white hairs; corolla small, deep blue or purple.—Low rich woods, Texas to Mississippi. Spring.

This differs very much from *T. Virginiana* in the longer, narrower leaves, pilose stems, and smaller flowers.—Probably is the Southern representative of *T. Virginiana*.

*Specimens examined:* Texas: Angelina County, *Reverchon* 4052, May 7, 1903, type (M); 4051, May 5, 1903 (M).

Mississippi: Coopolis, *Tracy* 5126, April 24, 1898 (M); Ocean Springs, *Skehan*, May 13, 1895 (M).

5. Tradescantia occidentalis Britton.

*Tradescantia occidentalis* Britton, Man. Nor. States & Can. 241. (1901).

Sandy woods and barrens, Western Missouri to Texas, Colorado, Utah and Montana, east to Nebraska. May to July.

*Specimens examined:* Missouri: Sheffield, Jackson County, *Bush* 733, June 10, 1900 (M). Nebraska: Anselmo, *Webber*, July 6, 1889 (M). Indian Territory: Catoosa, *Bush* 1265, May 8, 1895 (M). Oklahoma: Huntsville, *Laura A. Blankinship*, May 6, 1896 (M); no locality, *Waugh*, without date of collection (M); no locality, *Waugh* 204, without date of collection (M); Texas: Dallas, *Reverchon* 2189, April 18, 1900 (M); 2482, June 6, 1901 (M); Corsicana, *Reverchon* 2768, April 15, 1902 (M); Gillespie County, *Jermy*, without date of collection (M); Palo Duro Canyon, *Reverchon* 2769, April 30, 1902 (M); San Angelo, *Reverchon* 4053, May 20, 1903 (M); San Diego, *Nealley*, May, 1895 (N); Llano, *Bray*, May 14, 1902 (N); 513, May 15, 1899 (N); Tom Green County, *Tweedy* 203, May, 1880 (N); Midland, *Tracy* 8046, May 9, 1902 (N); Crab Apple, *Jermy*, without date of collection (N). Colorado: Denver, *Redfield* 8481, July 17, 1872 (M); Fort Collins, *Crandall*, July 10, 1897 (M); Fort Morgan, *Pammel* 300, June 23, 1896 (M); Cañon City, *Brandegee* 70, 1871 (M). Utah: Silver Reef, *Jones* 5154, May 3, 1894 (M). Wyoming: Fairbanks, *Aven Nelson* 492, July 14, 1894 (M): Ferris, *Elias Nelson* 4904, July 19, 1898 (M); Halleck Cañon, *Aven Nelson* 7455, July 4, 1900 (M); New Castle, *Pammel* 168, June 24, 1897 (M). Montana: Custer, *Blankinship* 57, June 12, 1890 (M).

6. Tradescantia reflexa Raf.

*Tradescantia reflexa* Raf. Atl. Journ. 150. (1832).

Abundant on prairies and in sandy woods, Virginia to

Florida, west to Texas, north to Missouri, Kansas, Michigan and Minnesota, east to Illinois and Ohio. May to July.

This species may be readily recognized by its robust stems and leaves, which are almost always very glaucous, and by its glabrous umbels. The Indian Territory specimens collected by Bigelow are referred by Dr. Rose to his *T. scopulorum*, but they appear to me better referable to *T. reflexa*, as they have stouter stems, larger leaves, larger umbels and much longer sepals than *T. scopulorum*, and exactly match Small's Oconee and Gwinnett Counties, Georgia, specimens, which are labeled *T. pilosa*.

*Specimens examined:* Virginia: Smyth County, *Small*, June 21, 1892 (M). North Carolina: Biltmore, *Biltmore Herbarium* 5745A, June 21, 1898 (M); 5745, June 20, 1897 (M). Georgia: Oconee and Gwinnett Counties, *Small*, July 14, 1893 (N); no locality given, *W. Jones* 8478, 1847 (M). Florida: Eustis, *Hitchcock*, June and July, 1894 (M). Louisiana: New Orleans, *Mellichamp*, March, 1898 (M). Ohio: Oberlin, *Hicks*, June, 1894 (M). Michigan: Decatur, *Dewey*, 257, June 22, 1895 (N). Iowa: Iowa City, *Hitchcock*, date of collection not given (M). Kansas: Riley County, *Norton* 526, May 25, 1895 (M); 526A, 1896 (M); Manhattan, *Norton*, August 25, 1892 (M). Missouri: Webb City, *Bush* 1611, May 12, 1902 (M); *Palmer* 299, May 18, 1902 (M); Independence, *Bush* 2568, June 25, 1892 (M); Monteer, *Bush* 551, May 15, 1894 (M); Jefferson Barracks, *Norton*, November 17, 1900, an old plant (M); Potosi, *Dewart*, June 3, 1892 (M); Jefferson City, *Dr. O. Krause*, June, 1866 (M); Cass County, *Broadhead*, May 26, 1864 (M); Saint Louis, *Pammel*, May 18, 1887 (M). Arkansas: Eureka Springs, *Bush* 1527, May 8, 1902 (M). Indian Territory: Sapulpa, *Bush* 472, April 29, 1895 (M); Banks of the Canadian River, near the 35th Parallel of Latitude, *Bigelow*, 1852–53 (N). Texas: Columbia, *Bush* 135, April 12, 1899 (M); Dallas, *Reverchon* 2188, April 18, 1900 (M); 2483, April 24, 1901 (M); 2767, May 1, 1902 (M); Swan, *Reverchon* 4050, June 3, 1903 (M); Industry, *Wurzlow*, 1895, 1897 (N).

7. Tradescantia scopulorum Rose.

*Tradescantia scopulorum* Rose, Contr. U. S. Nat. Herb. **5** : 205. (1899).

Much lower and more slender than *T. Virginiana*, to which it has been referred as an extremely narrow-leaved western form. This species appears to me to be more nearly related to *T. occidentalis*, from which it differs in the slender branching habit, narrow glaucous leaves, more numerous umbels, and in being glabrous throughout. Its range appears to be from Western Texas and Arizona to Montana, east to Western Nebraska. May to August.

*Specimens examined:* Texas: Marfa Creek, Presidio County, *Havard* 80, September, 1883 (N); Valley of the Rio Grande, below Dona Ana, New Mexico, *Mexican Boundary Survey* 1498 (N). New Mexico: Organ Mountains, Donna Ana County, *Wooton* 543, September 1, 1897, specimens with the umbels glandular-pubescent, sepals twice longer and narrower, approaches *T. occidentalis*, but otherwise agrees with the type, but may be an undescribed species (M N). Arizona: Santa Catalina Mountains, *Pringle* 13893, May 16, 1881, type (M); Snowflake, *Myrtle Zuck*, August 4, 1897 (M).

8. Tradescantia Wrightii Rose & Bush sp. nov.

Stems short, slender, simple and unbranched, 5–15 cm. tall, few-leaved, glabrous and glaucous, yellowish-green; leaf-blades narrowly linear, 5–10 cm. long, 1–3 mm. wide, straight, acuminate at apex, glabrous. Sheaths short, very pale, sometimes leafless, very smooth; bracts of the involucre 2, one long and one very short, smooth. Cymes sessile, small, single on the stems, few-flowered; pedicels short, apparently much flattened, often much twisted, glabrous, 5–15 mm. long; sepals lanceolate, obtuse, 3–5 mm. long, glabrous; corolla apparently very small, deep blue. — Mountains of western Texas. Summer.

Remarkably distinct from all the other species by its single, simple, sessile umbel, and its simple unbranched stems. Related very closely to *T. pinetorum*,* from which it is easily

* Greene, Erythea. **1** : 247. (Dec. 1893).

distinguished by its extreme smoothness. The precise locality where Wright collected his No. 701 is not known, but I presume it must have been in extreme Western Texas, probably near the Guadalupe Mountains, where Havard secured his specimens. Mr. C. B. Clarke in his description of *Tradescantia linearis* * in De Candolle's Monographiae Phanerogamarum,† refers Wright's No. 701 to that species, in which he is clearly in error, for that part of his description of *T. linearis*, "*umbella longe pedunculata, terminali, 3–4-radiata*," can not possibly apply to Wright's specimens in which the cymes are sessile.

*Specimens examined:* Texas: From Western Texas (San Antonio ?) to El Paso, *Wright* 701, May to October, 1849, type (N); foot-hills of the Guadalupe Mountains, *Havard*, date of collection not given (N).

9. Tradescantia vaginata Bush sp. nov.

Stems erect, stout at base, 3–5 dm. tall, much branched above, smooth and glaucous, branches very slender, ascending; leaf-blades long-linear, acuminate-attenuate, 2-4 dm. long, 2–6 mm. wide, straight or a little curved, conduplicate, very smooth. Sheaths very large and loose, papery, striking in appearance, smooth and glaucous; bracts of the involucre 2, linear, much shorter than the leaves, smooth. Cymes about 12-to 15-flowered; pedicels 1–3 cm. long, densely glandular-pubescent; sepals linear-lanceolate, acuminate, 10–15 mm. long, densely glandular-hirsute; corolla large, apparently pale blue.—Northern Texas. Summer.

Perhaps to be compared with *T. occidentalis*, from which it differs in the large papery sheaths, long linear leaves, much branched habit, and glandular-hirsute sepals.

*Specimens examined:* Texas: Lipscomb, Lipscomb County, *Arthur H. Howell* 78, July, 1903, type (N); 24, July 1, 1903 (N).

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* Benth. Plantas Hartwegianas. 27. (1839).

† Clarke, Monograph. Phanerogam. 3: 298–299. (1881).

10. Tradescantia gigantea Rose.

*Tradescantia gigantea* Rose, Contr. U. S. Nat. Herb. 5 : 205. (1899).

Appears to be more nearly related to *T. bracteata*, but is abundantly distinct in its almost velvety bracts, pedicels and sepals. — Sandy soil, Eastern Texas. Spring.

*Specimens examined:* Texas: New Braunfels, *Otto Locke*, April 14, 1897, type (N): Shovel Mount, Burnet County, *F. G. Schaupp*, May 22, 1897 (N); Gillespie County, *Jermy*, without date of collection (M); Big Sandy, Upshur County, *Reverchon* 2481, May 28, 1901 (M).

11. Tradescantia hirsuticaulis Small.

*Tradescantia hirsuticaulis* Small, Bull. Torr. Bot. Club. 24 : 233. (1897).

The range of this is now known to be from North Carolina to Texas, near the coast. It is readily distinguished from all the other species by the long brownish-hirsute pubescence of the stems and leaves.

Sandy soil, North Carolina to Florida, west to Eastern Texas. Spring.

*Specimens examined:* North Carolina: No locality given, *G. R. Vasey*, 1878 (N). Alabama: Tuscaloosa, *Ward*, April, 1892 (N). Louisiana: Alexandria, *Ball* 525, May 31, 1899 (M). Texas: Silver Lake, *Reverchon* 2190, May 21, 1900 (M): Mineola, *Reverchon* 2479, April 24. 1901 (M).

12. Tradescantia Reverchoni Bush sp. nov.

Stems solitary, erect, nearly straight, simple, 4–6 dm. tall, yellowish-green, densely appressed-pilose; leaf-blades linear, 2–3 dm. long, straight or a little curved, attenuate at tips, densely short-pubescent on both sides. Sheaths long-pilose; bracts of the involucre 2 or 3, narrowly linear, shorter than the leaves, densely pubescent like the leaves. Cymes with about 40 or 50 flowers; pedicels 1–2 dm. long, densely pilose with gland-tipped hairs; sepals lanceolate, acute, 10–12 mm. long, densely pubescent with gland-tipped hairs like the pedicels; corolla apparently large, blue.—Rocky Woods, Eastern Texas. Summer.

*Specimens examined*: Texas: The only specimens seen are those of the type collected at Lindale, Smith County, by *J. Reverchon* 2770, June 9, 1902 (M).

13. Tradescantia intermedia Bush sp. nov.

Stems erect, 2–4 dm. tall, simple or somewhat branched, pale yellowish-green, minutely roughish-pubescent and glandular; leaf-blades linear-lanceolate, 1–2 dm. long, 5–15 mm. wide, straight or somewhat curved, minutely pubescent beneath and ciliate on the margins, with long hairs on the midrib below. Sheaths large, loosely inflated, thin, smooth or sometimes minutely pubescent and ciliate on the margins; bracts of the involucre 2, unequal, resembling the leaves, but narrower. Cymes 10-to 15-flowered; pedicels 2–4 cm. long, thickly glandular pilose; sepals linear-lanceolate, obtuse, 6–9 mm. long, sparsely pilose with gland-tipped hairs, and with a cluster of long simple hairs at each apex: corolla small, rose-colored. — Sandy soil, Southern Texas. Spring.

This appears to be intermediate between *T. humilis* and *T. reflexa*, but differs in many respects from either of these species. I have referred the San Antonio specimens to this species, although they lack the long hairs on the back of the midrib, but this latter character may not be permanent.

*Specimens examined:* Texas: Industry, Austin County, *H. Wurzlow* 1155, of Rose Collection, April 6, 1897, type (N); San Antonio, *H. P. Attwater* 1156, Rose Collection, April 12, 1897 (N).

14. Tradescantia eglandulosa Bush sp. nov.

Stems short, erect, branched at the base, 1–2 dm. tall, roughish-pubescent, yellowish-green; leaf-blades linear-lanceolate, 1–2 dm. long, flat, thin, smooth above, pubescent with long hairs beneath, minutely ciliate on the margins. Sheaths much overlapping, short or almost none, very smooth, minutely ciliate on the margins: bracts of the involucre 2, somewhat unequal, shorter than the leaves, and like them. Cymes 10- to 15-flowered: pedicels 2–4 cm. long, densely pilose with yellow-brown hairs: sepals lanceolate, obtuse, 6–9

mm. long, hairy like the pedicels; corolla large, rose-colored. — Southern Texas.

This is conspicuously different from all the other Texas species, except *T. australis*, by the total absence of glandular pubescence.

*Specimens examined:* Texas: The only specimens seen are those of the type, collected in Gillespie County by *G. Jermy*, date of collection not given (M).

15. Tradescantia humilis Rose.

*Tradescantia humilis* Rose, Contr. Nat. Herb. 5: 204. (1899).

A very distinct species, probably the center of a group formed by the two last preceding species, and the two next immediately following. — Southern Texas. Spring.

*Specimens examined:* Texas: Industry, Austin County, *Wurzlow*, 1895, type (N); April 6, 1897 (N); San Antonio, *Reverchon* 4055, March 18, 1903 (M).

16. Tradescantia Texana Bush sp. nov.

Stems short, slender, weak, 1–2 dm. long, much branched, decumbent, appressed-pilose with ascending hairs, dark yellowish-green; leaf-blades linear-lanceolate, flat, thin, appressed-hairy on both sides, 5–10 cm. long. Sheaths almost none, hairy like the leaves; bracts of the involucre 2, broader than the leaves, broadest about the middle, thin, flat, hairy like the leaves, and with an aristate apex. Cymes 5- to 15-flowered; pedicels 1–3 cm. long, glandular-pubescent; sepals lanceolate, obtuse, 3–6 mm. long, densely glandular-pubescent; corolla small, deep blue or purple. — Sand hills, Texas. Summer.

I have been constrained to consider this distinct from any other species seen, by the peculiar appressed-hairy stems, notwithstanding the fact that Dr. Rose referred the specimens to his *T. humilis*, a very different species.

*Specimens examined:* Texas: The only specimens seen are those of the type, collected at Austin, Travis County, by *E. Hall* 669, May 18, 1872 (M N).

17. Tradescantia diffusa Bush sp. nov.

Stems diffusely branched, spreading, slender, 1–2 dm. long, bearing one or two leaves, roughish-pubescent and glandular throughout; leaf blades linear, 1–2 dm. long, 5–10 mm. wide, minutely pubescent above, long-hairy beneath, ciliate on the margins, flat, or a little curved, conduplicate. Sheaths very short, minutely pubescent, ciliate on the margins; bracts of the involucre 2, nearly equal, as long as, or longer than the leaves, and resembling them, somewhat saccate at the bases. cymes 5- to 10-flowered; pedicels 2–4 cm. long, slender, softly pubescent with gland-tipped hairs; sepals linear-lanceolate, obtuse, 4–6 mm. long, densely softly pubescent with gland-tipped hairs, and with a tuft of long simple white hairs at each apex; corolla very small, purple, blue or rose-colored. — Rocky ground, Southern Texas. Spring.

*Specimens examined:* Texas: The only specimens seen are those of the type, collected at San Antonio, by *E. H. Wilkinson* 168, March 14, year not given (M).

18. Tradescantia micrantha Torr.

*Tradescantia micrantha* Torr. Bot. Mex. Bound. 224. (1859).

This remarkable species is very distinct from all the other species in its creeping stems, short, wide, flat leaves and very small flowers. — Sandy soil, Southern Texas. Spring.

*Specimens examined:* Corpus Christi Bay, Nueces County, *Heller* 1564, April 9–12, 1894 (N).

*Issued December 30, 1904.*

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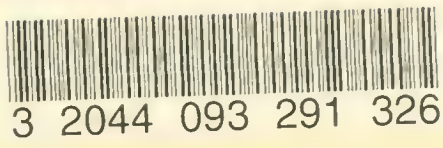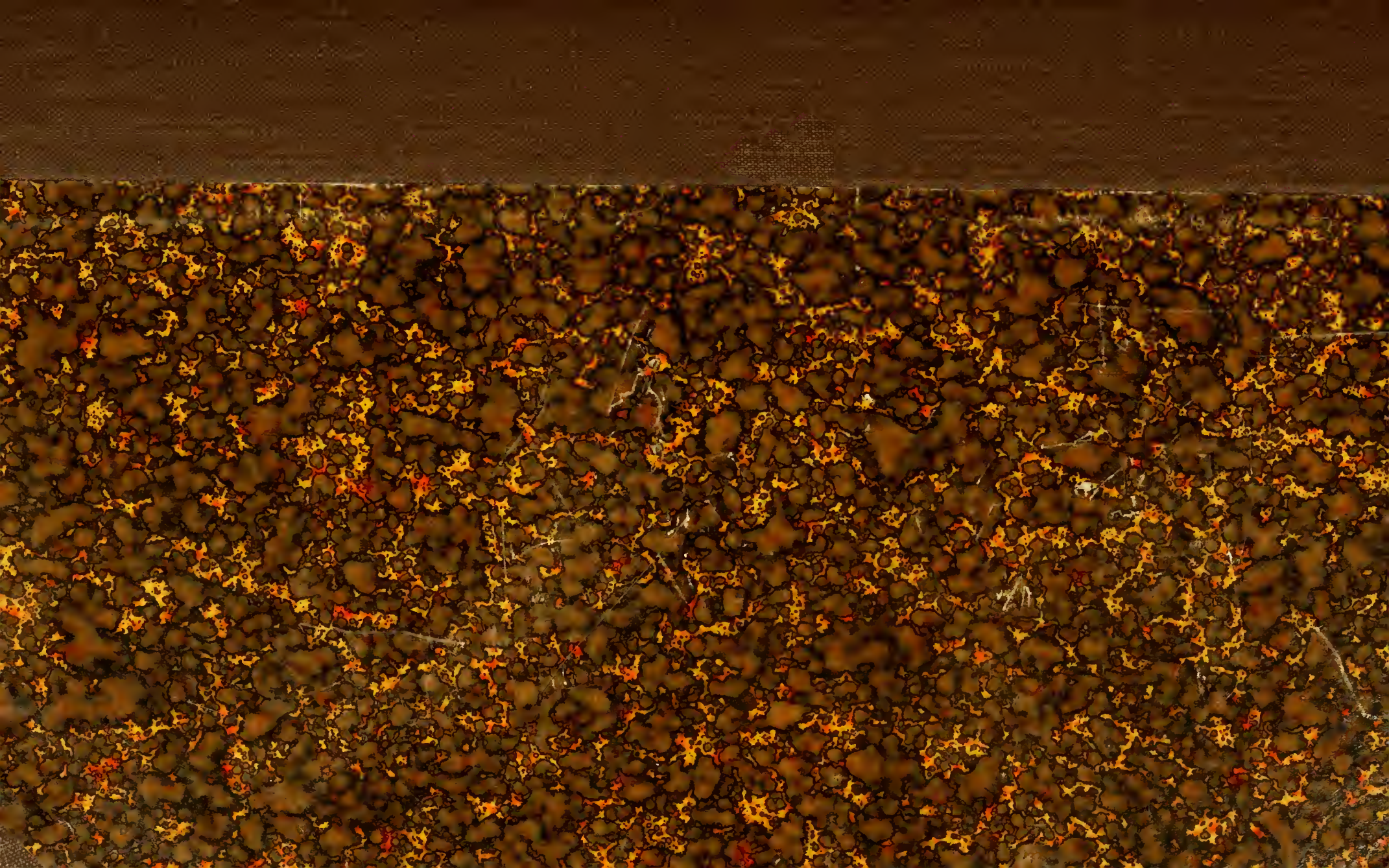
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